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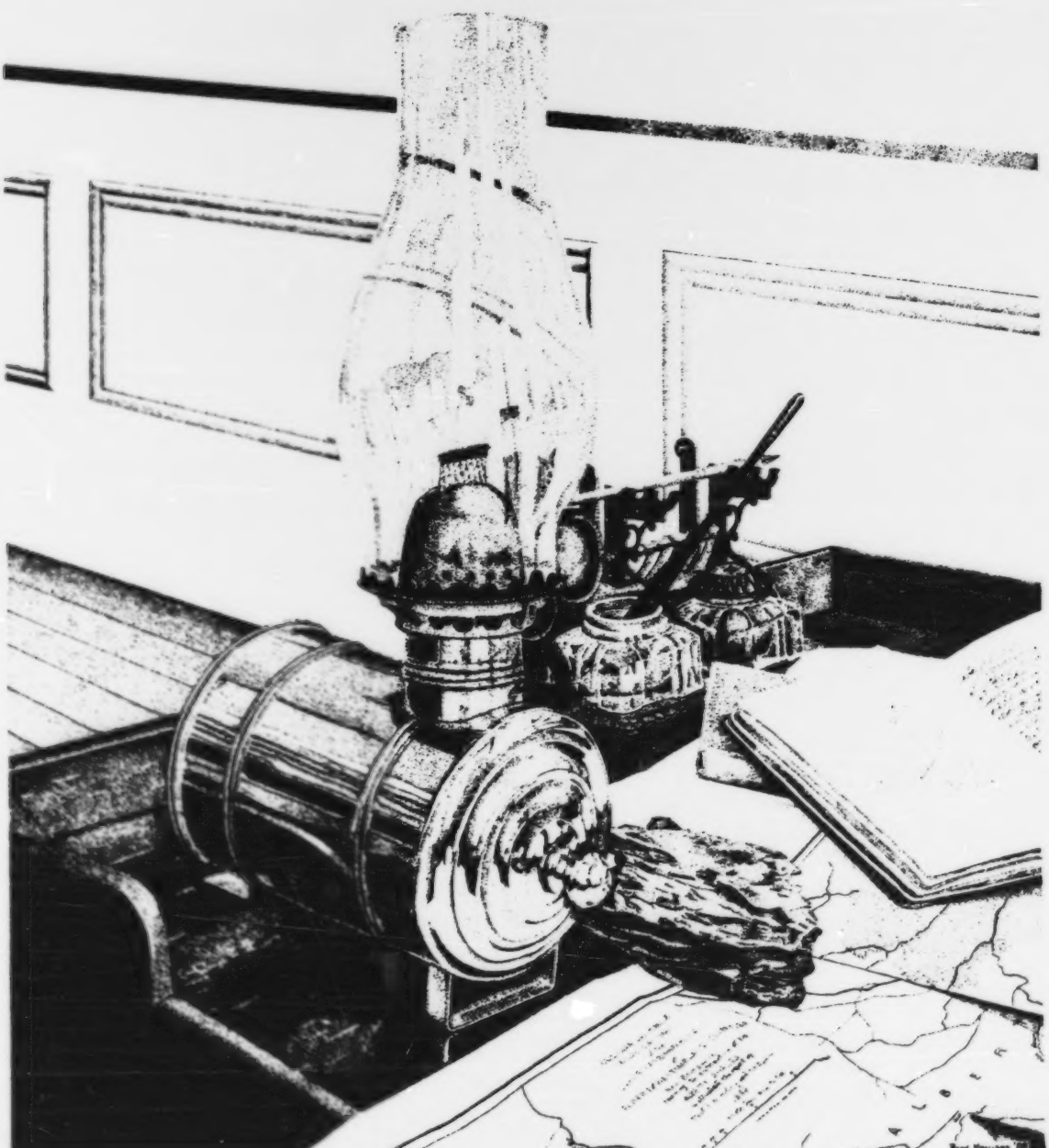
ASSESSMENT OF POTENTIAL SITES OF RECOVERABLE OIL SHALE IN NEW BRUNSWICK



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COVER SKETCH:

This angle lamp is a form of kerosene lamp that was developed in the early 1900's. It is a flame lamp, and when positioned correctly as the design intended, it eliminated the undershadow common to upright lamps. This Angle Lamp was photographed at Kings Landing Historical Settlement and makes up a part of their extensive collection of 19th century lighting devices.

The sketch was drawn by Brad Morrison of the New Brunswick Department of Natural Resources and Energy.

ASSESSMENT OF POTENTIAL SITES OF RECOVERABLE OIL SHALE IN NEW BRUNSWICK

Minerals and Energy Division

Department of Natural Resources and Energy

New Brunswick

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Plate 88-4 Bituminous shale Licence to Search and Lease location map, southeastern New Brunswick ..... in pocket
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ASSESSMENT OF POTENTIAL SITES OF RECOVERABLE OIL SHALE IN NEW BRUNSWICK

ABSTRACT

An assessment of organic matter and available calcium content in Albert Formation lacustrine oil shales was initiated following recent laboratory and pilot-scale tests which demonstrated that calcium-bearing oil shales are an effective sulphur sorbent when cocombusted with high-sulphur coal. The Upper Devonian/Lower Mississippian Albert oil shale beds are exposed in several places in the Moncton Subbasin of south-eastern New Brunswick. In the Rosevale, Dover, and Albert Mines areas there are sufficient drill-core and analytical data to make guarded estimates of resource potential.

Four drill holes in the Rosevale area intersect a 14 m thick shale bed with a strike length of 990 m. The bed has an average shale oil yield of 102 litres/tonne and contains an in-place reserve of over 2.5 million barrels to a depth of 100 m. The shale has a calcium content of 11.4 weight per cent and would provide about 460 000 tonnes of calcium.

Two drill holes in the Dover area cut an oil shale bed 11 m in thickness with an estimated strike length of 2350 m. The bed has an average shale oil yield of 98 litres/tonne and to a depth of 100 m contains an *in situ* resource of 8.4 million barrels. Four analyses for CaO by atomic absorption (AA) indicate a calcium content of 12% by weight. The calcium is mainly present in calcite and would therefore be available for sulphur gas neutralization.

Twenty-eight drill holes at Albert Mines intersect an oil shale bed with a strike length of 2050 m and an average thickness of 19.8 m. A reassessment of the geology at Albert Mines shows that the oil shale is repeated by two faults and this effectively doubles the tonnage of high-grade shale available at the surface. The bed has an average oil content of 95 litres/tonne and an in-place reserve of 5.8 million barrels to a depth of 100 m. Five analyses (AA) indicate that the shale may contain an average calcium content of 13.9 weight per cent which would provide about 800 000 tonnes of calcium to a depth of 100 m.

RÉSUMÉ

Une évaluation du contenu en matières organiques et en calcium accessible dans les schistes bitumineux de la formation lacustre Albert a été amorcée récemment à la suite d'essais en laboratoire et d'essais à l'échelle qui ont démontré que les schistes bitumineux calcifères absorbent de façon efficace le soufre lorsqu'on les fait brûler avec de la houille à forte teneur en soufre. La couche de schistes bitumineux Albert, qui remonte au dévonien supérieur/ mississippien inférieur, affleure à plusieurs endroits du sous-bassin de Moncton dans le sud-est du Nouveau-Brunswick. Dans les régions minières de Rosevale, Dover et Albert, on dispose de suffisamment de carottes de sondage et de données analytiques pour formuler, sous toutes réserves, des estimations de potentiel.

Dans la région de Rosevale, quatre trous de sonde entrecroisent une couche de schiste d'une épaisseur de 14 mètres et d'une longueur de 990 mètres. La couche possède un rendement moyen d'huile de schiste de 102 litres la tonne et les réserves sur place sont de plus de 2,5 millions de barils à une profondeur de 100 mètres. La teneur en calcium du schiste est de 11,4 unités de masse sur cent, soit 460 000 tonnes de calcium.

Deux trous de sonde percés dans la région de Dover entrecoupent une couche de schistes bitumineux de 11 mètres d'épaisseur et d'une longueur de 2350 mètres. La couche possède un rendement moyen d'huile de schiste de 98 litres la tonne et à 100 mètres de profondeur contient une ressource in situ de 8,4 millions de barils. Quatre analyses par absorption atomique (AA) de la teneur en calcium ont révélé qu'elle équivalait à 12% de la masse totale. Le calcium est surtout concentré dans la calcite et pourrait donc servir à neutraliser les émissions de gaz sulfureux.

À Albert Mines, 28 trous de sonde traversent une couche de schistes bitumineux d'une longueur de 2050 mètres et d'une épaisseur moyenne de 19,8 mètres. Une étude plus poussée de la géologie de la région révèle que le schiste bitumineux est multiplié par deux failles qui doublent réellement le tonnage de schiste à forte teneur directement accessible à la surface. La couche a une teneur en huile moyenne de 95 litres la tonne et représente une réserve sur place de 5,8 millions de barils à une profondeur de 100 mètres. Cinq analyses (AA) révèlent que le schiste pourrait contenir 13,9 unités de masse de calcium pour cent, soit environ 800 000 tonnes de calcium à une profondeur de 100 mètres.

INTRODUCTION

The New Brunswick Electric Power Commission (N.B. Power) and the Federal Department of Energy, Mines and Resources entered into an agreement in 1983 to develop a demonstration - scale circulating fluidized bed boiler in Chatham, New Brunswick. One of the objectives of this demonstration plant was to evaluate the potential for utilizing New Brunswick oil shale as a fuel and as a sorbent for removing sulphur gases when cocumbusted with New Brunswick's high sulphur coal. To this end N.B. Power signed an agreement with Canadian Occidental Petroleum Ltd. (Can Oxy) in 1985 by which Can Oxy would supply the necessary oil shale for the demonstration trials at the Chatham combustor. At the time of the N.B. Power - Can Oxy agreement, and at the time of this writing, Canadian Occidental Petroleum was the only company holding an oil shale permit or lease in New Brunswick. Accordingly, they were, and still are, the only company that could supply a large volume of shale on "quick notice".

The Energy Branch of the New Brunswick Department of Natural Resources and Energy was approached in early 1987 by N.B. Power to carry out an assessment of the potential sites where oil shale could possibly be mined in New Brunswick. Specifically, their request was to determine if the oil shale being supplied to Chatham by Canadian Occidental Petroleum Ltd. is the "best" shale available in New Brunswick. The word "best" is here defined as containing the highest possible content of available calcium (the effective sulphur sorbent) and at the same time containing an appreciable organic carbon content. An assessment of the relevant geological and analytical data is the subject of this report.

ACKNOWLEDGEMENTS

The author wishes to thank Shasta A. Abbott of the New Brunswick Department of Natural Resources and Energy for her many hours of painstakingly editing and formatting the report. William D. Smith of the Nova Scotia Department of Mines and Energy kindly reviewed

the text and offered constructive improvements.

A note of gratitude is extended to Laura Lee Williams for typing the original manuscript. The maps and diagrams were drafted by Gerard Johnson and Terry Leonard. Their help is hereby acknowledged.

HISTORY

The Albert Formation first gained attention in 1849 following the discovery of a vein of solid bitumen - later called albertite - cutting oil shales of the Formation at the present site of the Canadian Occidental Petroleum Ltd. lease at Albert Mines (Figure 1). The albertite vein was mined out during the mid-nineteenth century at which time the oil shales went relatively unnoticed. In 1927, W.J. Wright provided a summary of the oil shale resources at Albert Mines and Rosevale (Figure 1). He recorded the locations of boreholes, tunnels, and surface sites where assays were available.

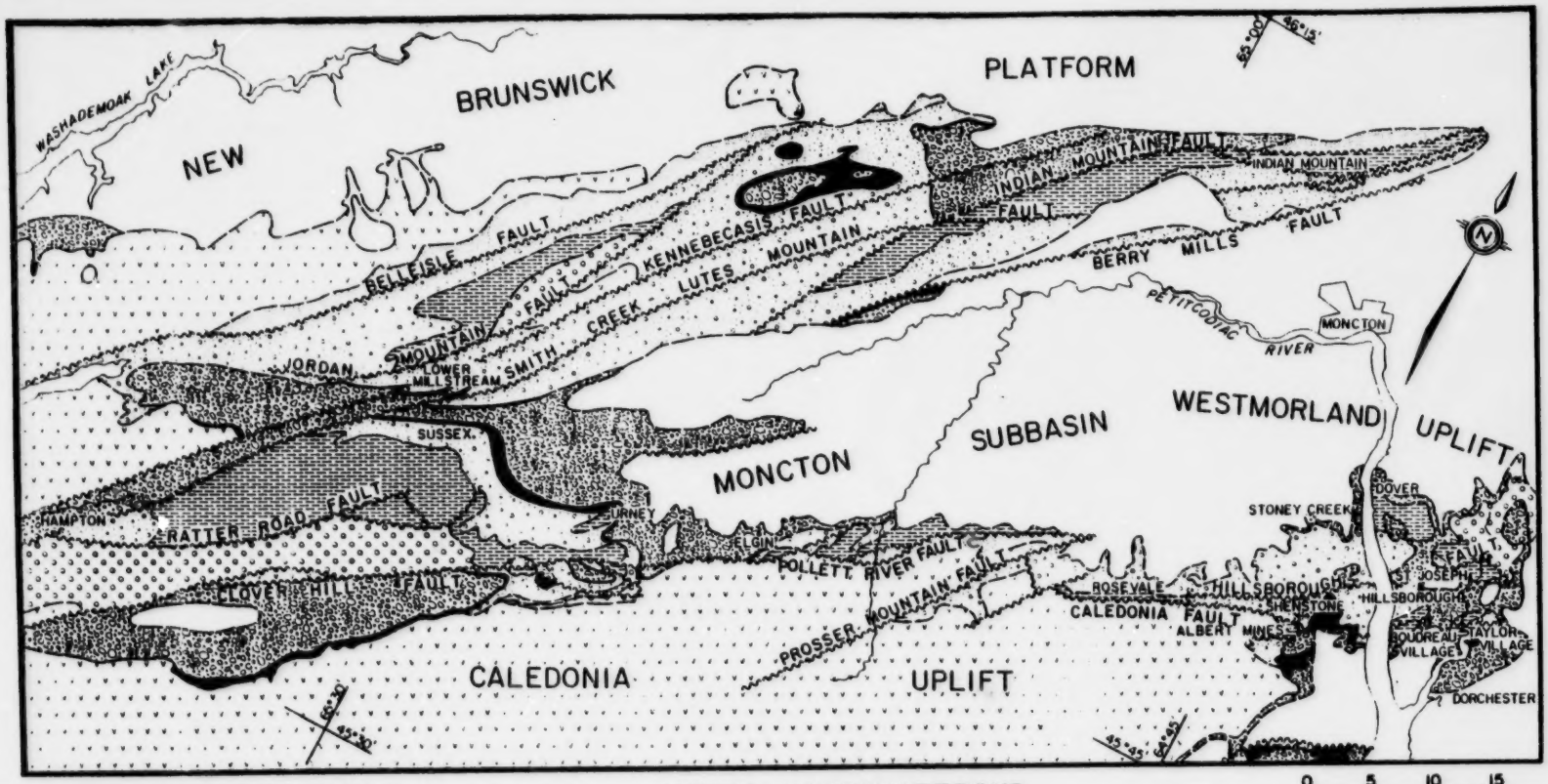
In 1942, the Canada Department of Mines and Resources utilized Wright's work and undertook a study of the oil shales of New Brunswick as part of a broader endeavour to secure petroleum supplies for the war effort. As part of this investigation, 36 holes were drilled at Albert Mines, 36 at Rosevale, and 7 at Taylor Village (Figure 1). The results obtained from Albert Mines were the most encouraging; there was an estimated 91 000 000 tonnes of shale to a depth of 120 metres averaging 53 litres of shale oil per tonne of rock (Alcock 1948).

Greiner (1962) completed a geological investigation of the Albert Formation and concluded that the oil shales of the Formation were mainly confined to the southeastern part of the Moncton Subbasin. In 1967 and 1968, the Atlantic Richfield Company (ARCO) used this idea and drilled ten deep holes to evaluate the oil shales at Urney, Saint-Joseph, Boudreau Village, Dover, Taylor Village, Rosevale, and Albert Mines (Figure 1). A major change in company philosophy led ARCO to drop their land holdings in New Brunswick in 1972.

In 1974 Canadian Occidental Petroleum Ltd. acquired bituminous shale (oil shale) licences for 29 159 hectares or nearly the entire Moncton Subbasin. Can Oxy commissioned Fundy Geoservices under the direction of J.K. Worth to undertake an evaluation of the surface geology and oil shale distribution and potential of the Albert Formation. Based on this assessment, and the drilling of one hole at Rosevale, one hole at Shenstone, and nine holes at Albert Mines, Can Oxy reduced their land holdings in 1981 to 1439 hectares, thereby retaining only the Albert Mines area (Plate 88-4). Can Oxy concluded from their coring and shale oil assay results that the Albert Mines site held the highest potential for the development of an oil shale mine. The possibility of using the oil shale for thermal power generation, or for utilizing the carbonate minerals in the shale as a sulphur-capturing media, were not considered in Canadian Occidental's evaluation or in choosing the Albert Mines site.

Petro-Canada acquired and held a bituminous shale Licence to Search in the Dover - Saint-Joseph - Taylor Village area of Westmorland County from 1981 through 1984. During that time, Petro-Canada drilled two holes near Dover and one at Boudreau Village. They analysed the intersected oil shale beds for shale oil content by Fischer Assay and Rock-Eval pyrolysis. A mineralogical assessment was undertaken by X-ray diffraction.

In 1985, Cartago Resources Ltd.



LOWER CARBONIFEROUS

- UNNAMED UNIT — RED AND GREY ALLUVIAL FAN AND FLUVIAL BEDS

UPPER DEVONIAN / LOWER CARBONIFEROUS

- ALBERT FORMATION — GREY ALLUVIAL FAN FLUVIAL AND LACUSTRINE BEDS
- MEMRAMCOOK FORMATION — RED ALLUVIAL FAN AND FLUVIAL BEDS

PRE-CARBONIFEROUS

- BASEMENT COMPLEX — IGNEOUS AND METAMORPHIC ROCKS

UPPER CARBONIFEROUS

- PETITCODIAC GROUP — GREY AND RED FLUVIAL BEDS
- HOPEWELL GROUP — RED AND GREY ALLUVIAL FAN AND FLUVIAL BEDS

LOWER CARBONIFEROUS

- WINDSOR GROUP — MARINE LIMESTONE AND EVAPORITES
- MONCTON FORMATION — RED AND GREY ALLUVIAL FAN AND FLUVIAL BEDS

COMPILED BY C. ST. PETER, 1987

0 5 10 15
SCALE IN KILOMETRES

FAULT

GEOLOGICAL BOUNDARY

FIGURE 1. Simplified geology of Moncton Subbasin, New Brunswick

of British Columbia took out a bituminous shale Licence to Search on the ground formerly held by Petro-Canada (Plate 88-4). In 1986, Cartago drilled a hole in the Dover area to extend the strike length of a high-grade bed discovered by Petro-Canada.

In 1982, the Department of Natural Resources initiated a program to reassess the Albert Formation and the Albert oil shales. Field investigations were carried out and several oil shale surface exposures were identified and analysed for shale oil content. Those exposures have not been further evaluated by follow-up trenching, drilling, or assaying and consequently there are insufficient oil yield data and carbonate analyses upon which to make a basin-wide assessment. The areas for which data are available - Rosevale, Dover, and Albert Mines - are described below.

TERMINOLOGY

Oil Shale: a fine-grained, sedimentary rock containing indigenous organic matter (kerogen), most of which is insoluble in petroleum solvents, and from which significant amounts of shale oil can be extracted by distillation or pyrolysis. There is nothing implicit in the definition with respect to inorganic mineral content. Oil shale, in addition to organic matter, contains silicate minerals that are dominantly quartz, feldspars, and clay minerals. Some oil shales, such as the Green River oil shale of Colorado or the Kukersite shale of Estonia (Yen and Chilingarian 1976), contain up to 56% carbonate minerals, most of which are calcite and dolomite. The Albert oil shale of New Brunswick contains silicate and carbonate minerals in varying quantities as will be described more fully below.

Shale Oil: the product recovered from the pyrolysis or destructive distillation of oil shale. The pyrolysis process occurs between 100 and 500°C and results in an undersaturated (hydrogen-deficient) shale oil product. Consequently, shale oil requires an additional refining step when compared with conventional petroleum.

Kerogen: the predominant organic substance in oil shale. It is derived from algae and lesser quantities of other simple forms of plant life. Kerogen by definition is insoluble in organic solvents and therefore cannot be separated from its rock matrix by solution. Oil shales are more appropriately called kerogen-bearing or kerogenous shales.

Bitumen: a minor organic component of oil shale. Bitumen by definition is soluble in carbon bisulphide, benzene, and similar organic solvents. For example, crude oil is derived from bitumens. The use of the term 'bituminous shale' to describe oil shale should be avoided.

GEOLOGICAL SETTING

The Moncton Subbasin of southeastern New Brunswick (Figure 1) underlies an area of about 3700 km^2. The Subbasin is situated in the southwestern part of the larger Maritimes Basin (Roliff 1962) (Figure 2). The rocks of the Maritimes Basin range from Middle Devonian to Lower Permian in age (Table 1) and are predominantly of continental origin except for the Windsor Group which comprises mainly marine limestone, sulphates, and chlorides. Details on the distribution, rock types, and ages of each group are given in Howie and Barss

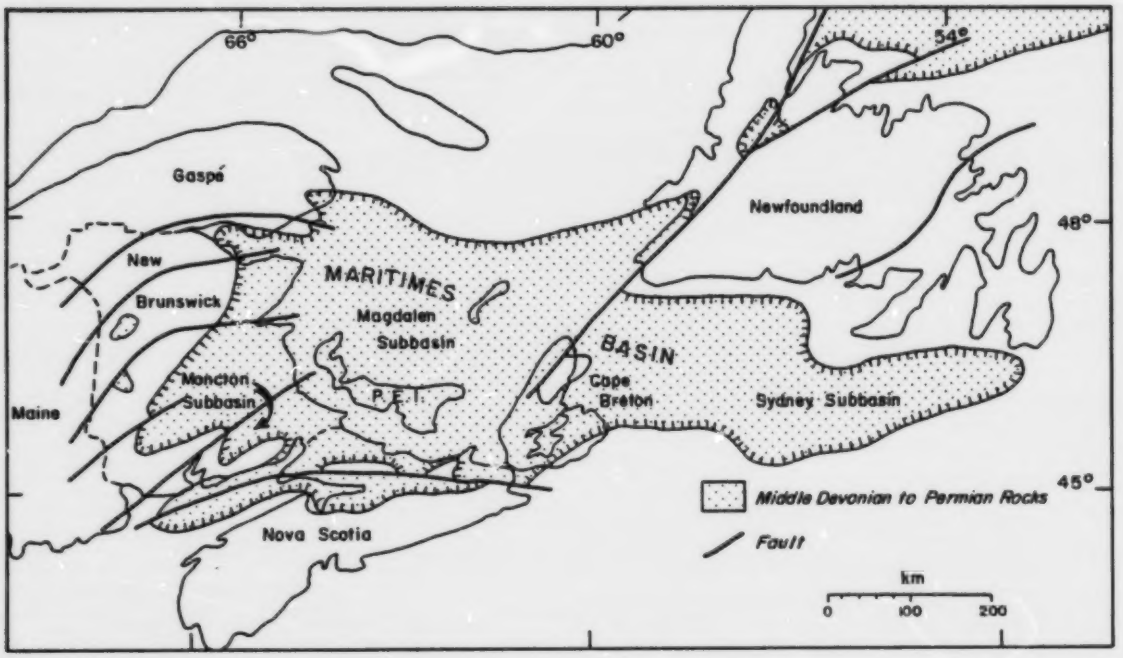


FIGURE 2. Distribution of Middle Devonian to Permian strata in the Maritimes Basin of eastern Canada showing the general location of the Moncton Subbasin (modified after Fyffe and Barr 1986).

(1974, 1975), Kelley (1967), Webb (1969), and Gussow (1953).

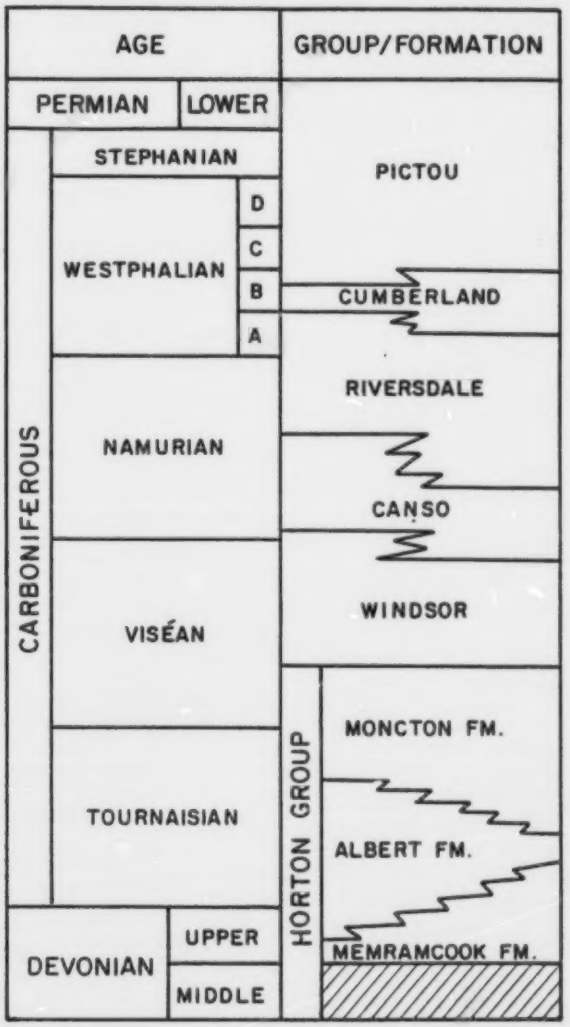
Horton Group rocks lie at the base of the Maritimes Basin sequence and in New Brunswick range in age from Upper Devonian to Lower Carboniferous (Table 1). The Horton Group in the Moncton Subbasin comprises basal red beds of the Memramcook Formation, overlying grey strata of the Albert Formation, and upper red beds of the Moncton Formation (Table 1). The Albert Formation thus comprises the medial formation of the Horton Group. The stratigraphy of the Horton rocks in New Brunswick has recently been reviewed and revised by Carter and Pickerill (1985).

The Albert Formation is exposed over an area of about 340 km^2 (34 000 ha) and comprises about 9% of the total surface area of the Moncton Subbasin. The distribution of the Albert Formation is shown in Figure 1. The Albert shale is known from boreholes, and is interpreted from seismic data, to occur in the subsurface over large parts of the Moncton Subbasin.

The Albert Formation consists of sedimentary rocks deposited in several closely spaced sedimentary subenvironments. The beds in the western part of the Subbasin are mainly deltaic and alluvial conglomerates, sandstones, and mudstones with only minor oil shale beds. The rocks in the northeastern part of the Subbasin are largely fine-grained deltaic sandstones and mudstones, and like the rocks to the west, have hardly any associated oil shales. The Albert Formation in the southeastern part of the Subbasin comprises coarse-grained alluvial

TABLE 1

STRATIGRAPHIC GROUPS AND AGES OF UPPER PALEOZOIC ROCKS OF THE MARITIMES BASIN* AND FORMATIONS OF THE HORTON GROUP IN NEW BRUNSWICK**



NOTES:
* modified after Howie and Barss 1975.
** after Carter and Pickerill 1985.

fan conglomerates and sandstones, deltaic sandstones and lacustrine mudstones, shales, and oil shales. The area from Urney eastward to Taylor Village (Figure 1) contains virtually all of the potentially exploitable oil shale.

About 1300 hectares or 4% of the surface area of the Albert Formation contains oil shale beds in sufficient quantity and/or thickness to comprise the major rock type in the local section. In most of the sections, there are insufficient subsurface and analytical data to make reasonable estimates of oil shale grades and tonnages. Sufficient data are available in the Rosevale, Dover, and Albert Mines areas to make guarded estimates of the scale of the oil shale resources.

OIL SHALES AT ROSEVALE

The Albert Formation at Rosevale (Figures 1, 3; Plate 88-4) is in fault contact to the south with Precambrian rocks of the Caledonia Uplift. To the north, the Albert rocks are unconformably overlain by red coarse-grained clastic rocks of the Hillsborough Member of the Moncton Formation (Norman 1941; Gussow 1953). The Albert strata at Rosevale comprise an interbedded sequence of kerogenous to non-kerogenous shale and mudstone, and minor dolostone, limestone, sandstone, and polymictic conglomerate. The strata dip at moderately steep angles toward the north-northwest.

Rock exposures along Turner Brook and Bray Brook reveal the presence of two prospective oil shale intervals (Figure 3). The potential of both intervals has in part been assessed by a Department of Natural Resources and Energy drilling and assay program carried out under the Canada-New Brunswick Mineral Development Agreement in 1985 and 1986 (Brown and Whaley 1986). Five of the six holes that were drilled during this project

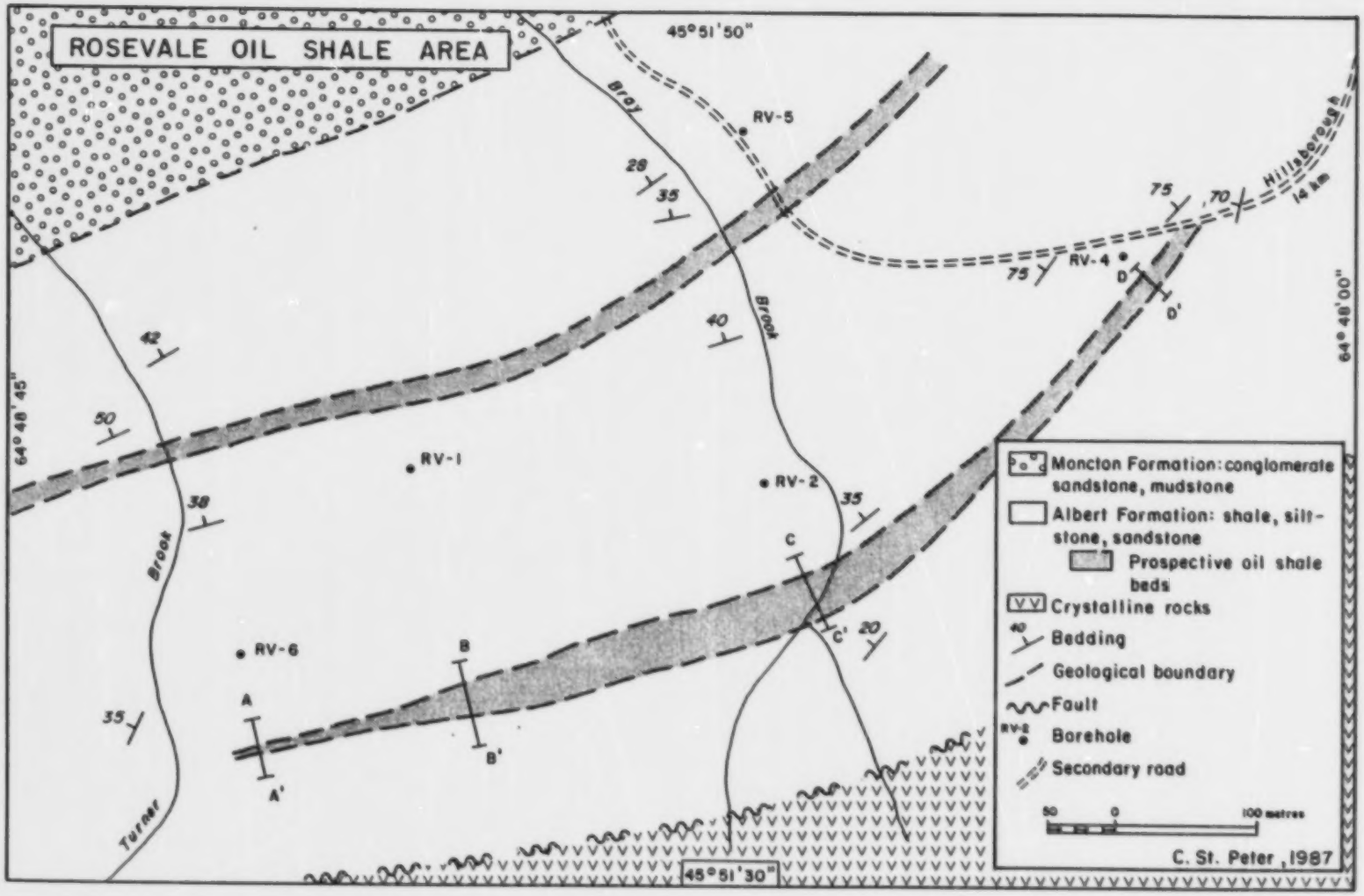


FIGURE 3. Geology of oil shale beds in Rosevale area (after Brown and Whaley 1986). See Plate 88-4 for location map.

are shown on Figure 3. The remaining hole, RV-3, was drilled 450 m west-northwest of RV-1 to test the western extension of the more northern oil shale interval.

The northern shale interval contains interbeds of kerogenous siltstone and fine-grained sandstone that effectively dilute the overall oil shale content. The interval ranges in thickness from 4.5 m in hole RV-3 to 11.5 m in RV-5. The shales in RV-3 and RV-5 have an average yield of 89.6 and 68.9 litres/tonne respectively. The limited thickness and moderate grades in the northern interval suggest that this shale has restricted potential.

The southern oil shale interval is an encouraging prospect. It has been informally named the Bray Brook zone by Brown and Whaley (1986). The analytical results from the four drill holes, RV-1, RV-2, RV-4, and RV-6, that intersect the zone are given in Appendix I.

The tabulated results in Appendix I require three brief explanations. First, the oil content in litres per tonne was not determined by the traditional Fischer Assay method. Each sample interval was analysed by Rock-Eval pyrolysis which provides, among other parameters, two essential outputs called S_1 and S_2. The S_1 output records the quantity of free hydrocarbons generated through thermal maturation in milligrams per gram of rock. The S_2 output records the quantity of hydrocarbons generated through the distillation of kerogen in milligrams per gram of rock. The sum of S_1 and S_2 gives the total hydrocarbon potential of the rock sample. The hydrocarbon potential when divided by the specific gravity of the shale oil - approximately 0.884 (Timm 1948) - gives the yield of oil in litres per tonne of rock. It is this calculated oil yield that is shown in Appendix I. Secondly, the carbonate carbon in each sample is determined by the difference in the quantity of total carbon and organic carbon. Thirdly, the values for equivalent calcium (Ca EQUIV.) are calculated by assuming that the only carbonate mineral present is calcite. The calcium value is thus determined by multiplying the quantity of carbonate carbon by 40/12, the atomic weight ratio of calcium to carbon in pure calcite. Analogous equivalent calcium values can be generated by assuming that dolomite $(Ca,Mg)CO_3$ is the only carbonate mineral present. In this case, the carbonate carbon content is multiplied by 20/12, which is the atomic weight ratio of calcium to carbon in pure dolomite. The oil shales are known to contain both calcite and dolomite (Macauley and Ball 1982) and therefore the equivalent calcium values may be somewhat less than those shown in Appendix I.

A summary of the analytical data from Appendix I is given in Table 2. The thickness of the Bray Brook zone in each drill hole is calculated utilizing the bedding to drill-core angles given by Brown and Whaley (1986).

The potential shale oil and calcium reserves for the Bray Brook zone are given in Table 3. The reserves were calculated by using the following assumptions and methods:

1. The zone has an average northwesterly dip of 45°.
2. The depth for the reserve determination is taken at 100 m below the level of the projected surface trace of the interval.
3. The stripping ratio is not taken into account.
4. The kerogenous beds overlying the Bray Brook zone are not recovered during excavation.

5. There is no dilution.
6. The density of the oil shale is assumed to average 2.2 tonnes/m^3 (Macauley and Ball 1982).

The volume of shale in the Bray Brook zone is determined by constructing four cross-sections, A-A', B-B', C-C', and D-D' as shown on Figure 3. The cross-sections are oriented perpendicular to the local strike of the zone, that being determined by surface exposures on Turner Brook and Bray Brook. The thickness (t) of the zone on each cross-section is that determined from the associated drill hole. For example, the thickness in RV-1 is 26.27 m (Table 2) and the thickness on corresponding section B-B' (Figure 4) is taken as 26.27 m. The area (a) of the zone on each cross-section is calculated by assuming an average dip of 45° and determining the area of the corresponding inclined interval. The area is the product of the thickness (t) and 100/sin 45° = 127(t) square metres.

To determine the volume of the Bray Brook zone, the area for each cross-section is multiplied by an associated length factor (k) to give an integral volume (v). The length factor is the sum of one-half the distances between adjacent sections. For example, the length factor associated with cross-section B-B' is the sum of: (a) one-half the distance between B-B' and A-A', and (b) one-half the distance between B-B' and C-C'. In the case of cross-sections A-A' and D-D', (k) is taken as two times one-half the distance between A-A' and B-B', and D-D' and C-C' respectively. The above calculations give a total length for the Bray Brook zone of 990 m and a total volume of 1 814 808 m^3 (Table 3).

The weight of oil shale associated with each integral volume (v) is obtained as the product of that volume and the rock density of 2.2 tonnes/m^3 (Macauley and Ball 1982). The shale oil content in litres is then calculated by multiplying the weight in tonnes by the yield data from Table 2. It is thus determined that to a depth of 100 m there are greater than 400 000 000 litres or about 2.5 million barrels of shale oil in place in the Bray Brook zone. A greater volume of oil could be recovered by selectively mining kerogen-rich beds above the Bray Brook zone.

The total number of tonnes of calcium in the Bray Brook zone is determined by assuming that the only carbonate mineral present is calcite. Using the same volume and weight calculations as described above and shown in Table 3, there are 462 671 tonnes of calcium in the zone to a depth of 100 m.

OIL SHALES AT DOVER

In the Dover area (Figures 1, 5; Plate 88-4) the Albert Formation is in part unconformably overlain by the Upper Mississippian or Lower Pennsylvanian conglomerates and sandstones of the Enragé Formation. The Albert strata are exposed as a window through the Enragé and comprise a gentle south-dipping sequence of lacustrine shale, siltstone, and fine- to medium-grained sandstone. Within this sequence there are intervals dominated by oil shale beds of varying grades. Three such intervals have been determined by three boreholes - Petro-Canada Dover No. 1, Petro-Canada Dover No. 2, and Cartago Resources Limited Dover No. 1 - and from surface grab samples. The two northern intervals (Figure 5), where they are exposed on Downing Creek, contain beds of low to moderate shale oil yield. East of Downing Creek, grades and thicknesses are not well defined

TABLE 2

SUMMARY OF ANALYTICAL DATA FOR THE BRAY BROOK ZONE AT ROSEVALE, NEW BRUNSWICK*

HOLE	INTERVAL (m)	THICKNESS (m)	YIELD (L/tonne)	CARBONATE CARBON (wt.%)	Ca EQUIV. (wt.%)
RV-1	117.4 - 155.2	26.27	86.28	3.40	11.32
RV-2	56.0 - 74.6	17.67	102.30	3.91	13.05
RV-4	47.4 - 60.6	9.33	126.23	3.02	10.07
RV-6	68.6 - 72.2	3.53	94.97	2.68	8.92

Note:
* see Figure 3 for drill-hole locations

TABLE 3

POTENTIAL RESERVES OF SHALE OIL AND CALCIUM IN THE BRAY BROOK ZONE, ROSEVALE, NEW BRUNSWICK*

SECTION	THICK. t (m)	SECT. AREA a=tx127(m^3)	LENGTH (m)	VOLUME v=axk(m^3)	WEIGHT tonnes	YIELD litres	YIELD bbl.	CALCIUM tonnes
A-A'	3.53	448	153	68 544	150 797	14 321 190	90 078	13 451
B-B'	26.27	3336	205	683 880	1 504 536	129 811 366	816 490	170 313
C-C'	17.67	2244	296	664 224	1 461 293	149 490 274	940 267	190 699
D-D'	9.33	1185	336	398 160	875 952	110 571 421	695 475	88 208
		TOTAL	990	1 814 808	3 992 578	404 194 251	2 542 310	462 671

Note:
* see Figure 3 for section locations

since there are few exposures of the shales. The two intervals are not considered prospective at this time based on the data from the Downing Creek sections.

The third and most southerly oil shale bed has been intersected in the Petro-Canada Dover No. 2 (PCAN-2) and Cartago Resources Limited Dover No. 1 (CRL-1) holes (Figure 5). This shale will informally be called the Boyd Creek bed. Data from the PCAN-2 hole and the CRL-1 hole are summarized in Appendix II. The Boyd Creek bed was intersected in the PCAN-2 hole

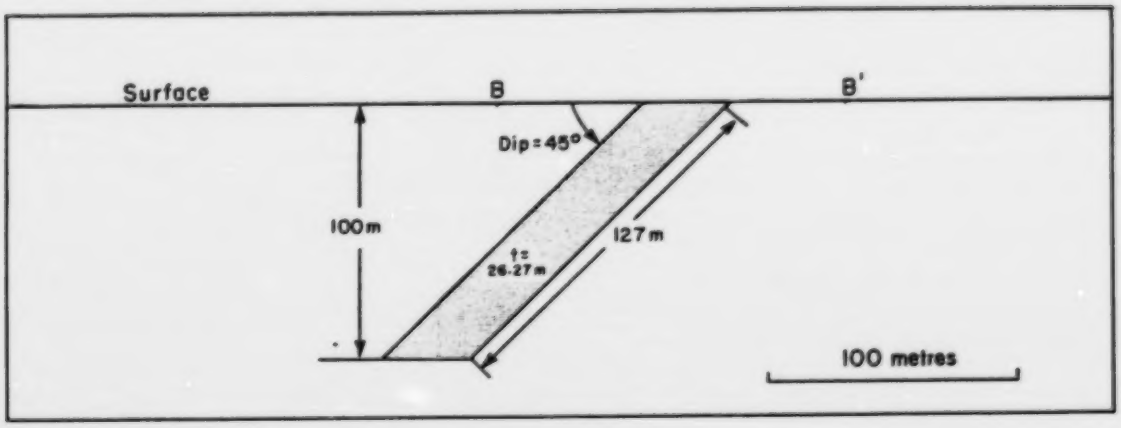


FIGURE 4. Schematic cross-section B-B' of Bray Brook oil shale zone.

between 116.40 and 128.46 m with an average Fischer Assay yield of 88.7 litres/tonne (Wright 1982). The dip of the strata along this part of Boyd Creek is about 20° (St. Peter, unpublished data). Therefore, the true thickness of the Boyd Creek bed at PCAN-2 is (128.46-116.40) cos 20° = 11.34 m. At CRL-1, the Boyd Creek bed was cut between 69.34 and 82.14 m with an average calculated yield of 107.13 litres/tonne (Ball 1986). Core to bedding angles give an average dip of 31° and consequently the Boyd Creek bed is (82.14-69.34) cos 31° = 10.97 m thick at CRL-1.

For the purpose of calculating the oil shale reserves for the Boyd Creek bed, the recoverable depth for surface mining is taken at 100 m. The stripping ratio is not considered. Kerogenous beds overlying the Boyd Creek bed are not included in the reserve calculations and it is assumed that there is no dilution.

The volume of shale in the Boyd Creek bed is determined by the same method as described above for the Rosevale area. The locations of two cross-sections, A-A', and B-B' are shown on Figure 5. The thickness (t) of the bed on each cross-section is that calculated from the associated drill hole (Figures 5 and 6). The area (a) of the bed on each cross-section is derived from the product of the thickness and 100/sin(dip). The volume of the Boyd Creek bed is determined by multiplying the cross-sectional areas by an associated length factor (k) to give an integral volume (v) (Table 4). The length factor associated with cross-section A-A' is the distance from the Albert Formation/Enragé Formation contact northwest of PCAN-2 (Figure 5) eastward to a point midway between cross-sections A-A' and B-B'. The length factor associated with cross-section B-B' is the sum of one-half the distance between cross-sections A-A' and B-B' and an equal distance from B-B' to the east.

The weight of oil shale related to each integral volume (v) is obtained by the product of the volume and the rock density of 2.18 tonnes/m^3. Smith (1985) determined an average density of 2.18 gm/cm^3 or 2.18 tonnes/m^3 from fourteen samples of organic-rich oil shale in the Dover and Albert

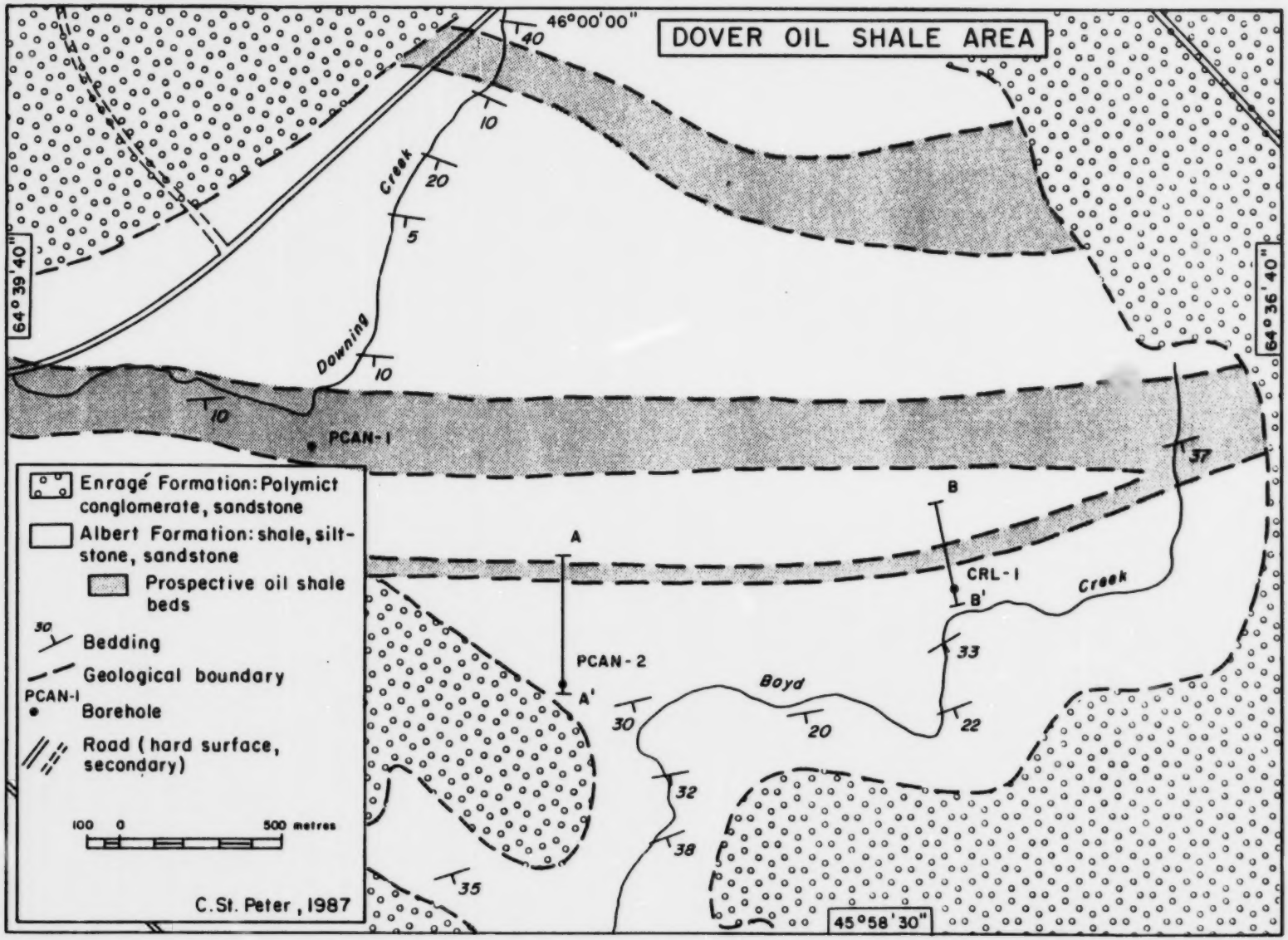


FIGURE 5. Geology of oil shale beds in Dover area. See Plate 88-4 for location map.

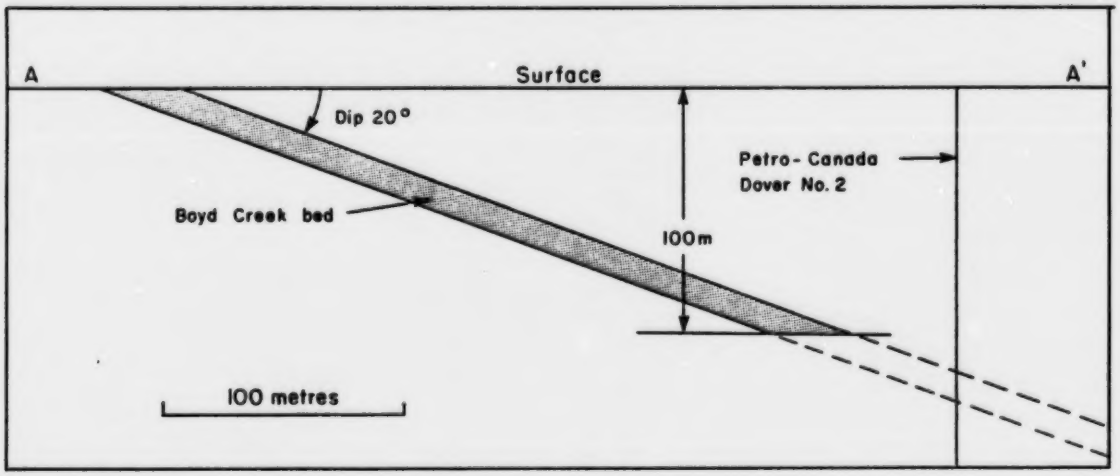


FIGURE 6. Schematic cross-section A-A' of Boyd Creek oil shale bed. See FIGURE 5 for location.

TABLE 4

POTENTIAL RESERVES OF SHALE OIL IN THE BOYD CREEK BED, DOVER, NEW BRUNSWICK*

SECTION	THICKNESS t (m)	CROSS-SECT. AREA a=tx100/sin(dip)(m^2)	LENGTH (m)	VOLUME v=axk(m^3)	WEIGHT tonnes	YIELD litres	YIELD bbl.
A-A'	11.34	3316	1180	3 912 880	8 530 078	756 617 918	4 758 992
B-B'	10.97	2130	1170	2 492 100	5 432 778	582 013 507	3 660 761
		TOTAL	2350	6 404 980	13 962 856	1 338 631 425	8 419 753

Note:
* see Figure 5 for section locations

Mines areas.

The shale oil content in litres is calculated by multiplying the weight in tonnes by the yield data from the associated drill hole (Table 4). To a depth of 100 m there are greater than 1 billion litres or about 8.4 million barrels of shale oil in place in the Boyd Creek bed.

The 13 962 856 tonnes of oil shale (Table 4) in the Boyd Creek bed may have an average equivalent calcium content as high as 12% (Appendix II). This is based on four analyses from the Petro-Canada

Dover No. 2 hole (Smith 1985). The Ca determination assumes that the total weight per cent CaO present would be available as an effective sorbent for sulphur capture. This is not likely to be the case if there are appreciable amounts of non-carbonate calcium-bearing minerals present, in which case the Ca available for reaction with sulphur oxide gases will be somewhat less than 12%.

In summary, the Boyd Creek oil shale bed is an encouraging prospect. Several shallow drill holes and surface trenches, followed by systematic sampling with resulting organic geochemical and carbonate analyses are required to provide a more definitive assessment of the resource at Dover. The two northern oil shale intervals require further exploration to the east of Downing Creek.

OIL SHALES AT ALBERT MINES

Oil shales were first identified along Frederick Brook in 1841 by Dr. Abraham Gesner (Plates 87-62(R), 88-4). The area later received the name Albert Mines following 1849 when a vein of black vitreous solid bitumen - called albertite - was discovered cutting the oil shales along the brook (Plate 87-62(R)). The albertite vein was mined along a northeasterly strike for 850 m and to a maximum depth of 400 m (Ells 1909; Cunningham-Craig 1916; Wright 1922).

The Albert Formation at Albert Mines is in tectonic contact to the south, west, and north with adjacent rock units. To the south, north, and northeast the Albert strata are in fault contact with red to grey mudstones, sandstones, and debris-flow conglomerates of the Moncton Formation. To the west, the Albert beds are faulted against volcanics of the Precambrian Coldbrook Group (Worth 1975; McLeod 1980). To the southeast, the section is unconformably overlain by Mississippian or Pennsylvanian red beds of the Enragé Formation (Alcock 1948; McLeod 1980; Pickerill et al. 1985).

The structure of the Albert strata at Albert Mines has been shown at various map scales as a large-scale south-plunging anticline with a hinge line approximately following the trend of Frederick Brook (Wright 1922; Alcock 1948; Worth 1975). However, Wright (1922), and later McLeod (1980), recognized that the structure is in fact much more complex than a single fold. It has been known for over 100 years that the albertite vein occupies a fault breccia zone (Dawson 1853; Milner 1912; Cunningham-Craig 1916). The oil shales in the area are in many places folded and brecciated (Wright 1922; Alcock 1948; Macauley and Ball 1982; St. Peter 1987). Faults (apparently with little displacement) offset the albertite vein in the underground workings (Dawson 1853; Hitchcock 1865). Careful documentation of structural features and younging directions in surface exposures and a reassessment of borehole data show that an east-northeast-trending fault cuts the Albert strata from the Precambrian basement in the west to the albertite vein in the east (Plate 87-62(R)). This fault is named the Gesner Fault in honour of Dr. Abraham Gesner. The Gesner Fault offsets right laterally a second fault that lies subparallel to, and on the northwest side of, the albertite vein. Wright (1922, p.42) implied the existence of this second fault when he described the intense crumpling of the beds on the north side of the albertite vein. For this reason the second fault is

called the Wright Fault.

The Albert strata on the north side of the Gesner Fault and on the northwest side of the north part of the Wright Fault are, for descriptive purposes, referred to herein as Block 1. The strata in Block 1 are folded into a gentle- to moderate-plunging anticline (the historic Frederick Brook anticline) and a south-plunging syncline. The existence of the syncline is evidenced from the known west-dipping beds in boreholes 40, 45, and 56 and the east-younging beds on the western limb of the fold exposed south of Canadian Occidental Petroleum drill hole, COXY 76-7 (Plate 87-62(R)).

The Albert beds on the south side of the Gesner Fault and on the west side of the Wright Fault are herein referred to as Block 2. The beds in Block 2 along Frederick Brook are steeply to vertically dipping and folded into mesoscopic folds (Plate 87-62(R)).

The beds on the southeast side of both parts of the Wright Fault are referred to as Block 3. The strata dip moderately to steeply to the south and southeast. Along the southern part of Frederick Brook, the beds are overturned to the south in proximity to the fault juxtaposing the Albert Formation against the Hillsborough Member of the Moncton Formation.

The structural complexities at Albert Mines have historically resulted in considerable difficulty in describing the stratigraphy and facies relationships. The structural synthesis described above has clarified many problems. The Albert Formation is seen to comprise two major facies, designated Ma_f and Ma_c on Plate 87-62(R). The rocks in facies Ma_c comprise fine- to coarse-grained, grey, micaceous sandstone, grey polymictic, pebble-boulder conglomerate, grey mudstone, and minor limestone, kerogenous siltstone, and kerogenous shale. The conglomerate beds are restricted to the western parts of Blocks 1 and 2. They were intersected in borehole COXY 76-7 where they comprise 20% of the section. The absence of conglomerate in COXY 76-4 to a depth of 521 m suggests that the coarse facies Ma_c interfingers to the east with the fine-grained facies Ma_f.

The strata of facies Ma_f comprise brown, slightly to moderately kerogenous siltstone and shale. The facies also contains beds of highly kerogenous shale (oil shale) that are typically less than 5 m in thickness. The rocks of facies Ma_f constitute the type section of the Frederick Brook Member of the Albert Formation as defined by Greiner (1962). Within this facies there is a brown, moderate to highly kerogenous, thick oil shale bed designated as unit Ma_s on Plate 87-62(R). The bed is exposed along Frederick Brook where at the collar of borehole 52 it was designated as oil shale bed no. 1 by Wright (1922). The bed is seen at several other outcrops and in borehole intersections. The geometry of this bed has facilitated the structural interpretation shown on Plate 87-62(R).

Since the discovery of oil shales at Albert Mines various estimates of reserves have been made. Ells (1903) considered the quantity of oil shale practically unlimited. Wright (1922) established, from tunnel channel samples and surface grab samples, that the oil shale beds vary considerably in grade. He mapped the location of five promising oil shale beds near Frederick Brook and suggested a deposit containing millions of tons. Alcock (1948) described the results

of a 1942 Federal Government drilling program wherein 4000 m of core was drilled in 36 holes. The locations of these holes are shown on Plate 87-62(R). By disregarding stratigraphy and structural complications, he determined that in a block 730 m in length (NE-SW) by 490 m in width (NW-SE) and to a depth of 120 m, that there are 91 000 000 tonnes of oil shale. The average yield of this shale is 53 litres/tonne and would provide about 30 000 000 barrels (bbl.) of shale oil.

Macauley and Ball (1982) calculated reserves using Fischer Assay data on continuously sampled core drilled by Atlantic Richfield Company and Canadian Occidental Petroleum Limited. The Atlantic Richfield and Canadian Occidental holes are shown on Plate 87-62(R). Macauley and Ball (1982) estimated that the highest grade zone in the area is about 60 m wide and that in a block 1200 m in length to a depth of 600 m, this high-grade zone contains an in situ reserve of 67 300 000 bbl. of shale oil.

Previous oil shale and shale oil reserve estimates at Albert Mines have disregarded the complications caused by faults and folds. The structural complexities have been avoided by determining the reserves for all rocks in a three-dimensional block. The assessments have been made by using Fischer Assay results from drill-core intersections and employing mass averages (Alcock 1948).

In the method of assessment used for this study, only the reserves for the organic-rich bed Ma_s are estimated. It is reasoned that in the future when the oil shale is mined, the most organic-rich bed will be given highest priority. At that time, thinner high-grade beds lying above bed Ma_s may be selectively recovered in an above-ground mining operation. To calculate the reserves in bed Ma_s, the area is divided into Block 1, Block 2, and Block 3 as defined above. In all three blocks the following assumptions or criteria are used:

1. The depth for the reserve determination is taken at 100 m below the level of the surface trace of the bed.
2. The stripping ratio is not taken into account. The soil cover ranges from 1 to 3 m.
3. There is no dilution.
4. The density of the oil shale averages 2.18 tonnes/m^3 (Smith 1985).

Oil shale bed Ma_s has been intersected in 28 drill holes at Albert Mines (Plate 88-62(R)). The drilling companies, hole numbers, bed Ma_s intersections, Fischer Assay intervals, and the shale oil yields are tabulated in Appendix III. The true thickness of the bed in each hole has been determined using the drilling intersection length and the core to bedding angles. These data, along with a summary of the average shale oil yield in litres/tonne, are given in Table 5.

In Block 1, bed Ma_s was intersected in Government of Canada boreholes 38, 40, 47, 51, 52, 56, 59, and 73, and in Canadian Occidental Petroleum holes COXY 4, COXY 6, and COXY 81-9. A complete section of bed Ma_s is observed in ten of the holes. The ten sections give an average bed thickness of 16.35 m (Table 6). The bed in Block 1 is assumed to have an average dip of 45°, and therefore to a depth of 100 m the cross-sectional area of the bed is 2312.6 m^2 (Table 6). The surface length of the bed in Block 1 is 1050 m (Plate 87-62(R) and Table 6). The volume of oil shale in the bed to a depth of 100 m

TABLE 5

SUMMARY OF INTERSECTION LENGTHS, THICKNESSES, AND YIELDS FOR BOREHOLES CUTTING BED Ma_s AT ALBERT MINES, NEW BRUNSWICK*

HOLE	LENGTH (m)	CORE AXIS TO BEDDING ANGLE (degree)	THICKNESS (m)	AVG. YIELD (L/tonne)
38	49.39	36.7	29.54	112.2
40	19.51	56.8	16.33	90.8
41	27.44	49.5	20.85	92.5
42	22.26	74.8	21.48	87.6
47	10.36'	45.0	7.32	97.9
48	24.91	44.8	17.51	97.2
51	28.99	45.0+	20.49	99.8
52	15.24'	80.0+	15.01	107.8
55	59.46	25.4	25.57	76.7
56	14.94	76.5	14.52	79.1
57	68.59	18.0	21.19	95.2
58	43.60	48.0	32.39	103.4
59	15.25	36.3	9.01	108.2
59	9.15	90.0	9.15	75.8
73	39.63	26.0	17.36	96.3
74	35.06	36.1	20.65	84.5
75	16.77	32.9	9.14	90.0
77	8.53'	11.2	1.64	103.9
77	9.14'	27.5	4.22	89.0
78	16.77	72.5	16.00	92.3
79	18.29	69.8	17.17	83.1
81	13.72'	50.0	10.51	94.8
83	52.13	32.1	27.73	86.8
ARCO A1	68.29	22.9	26.56	115.8
COXY 1	34.75	29.6	17.17	105.3
COXY 2	96.96	27.5	44.80"	114.3
COXY 4	45.73	30.0+	22.87	96.5
COXY 5	85.37	25.8	38.48	113.8
COXY 6	12.19	44.5	8.55	89.0
COXY 81-9	24.39	45.5	17.39	96.7

+ Estimated
' Incomplete section of bed Ma_s
" Anomalous thickness believed to result from location on closure of fold (see Plate 87-62(R))

Note:
* see Plate 87-62(R) for borehole locations

TABLE 6

POTENTIAL RESERVES OF SHALE OIL IN OIL SHALE BED Ma_s AT ALBERT MINES, NEW BRUNSWICK.

RESERVES CALCULATED TO A BED DEPTH OF 100 METRES*

BLOCK	BED THICK. t (m)	BED DIP degree	CROSS-SECT. AREA a=tx100/sin(dip(m^2)	LENGTH (m)	VOLUME v=axk(m^3)	WEIGHT tonne	AVG. YIELD L/tonne	YIELD bbl.
1	16.35	45	2312.6	1050	2 428 230	5 293 540	93.4	2 800 000*
2	23.32	75	2414.0	600	1 448 400	3 157 512	93.2	1 850 970
3	19.71	70	2097.0	400	838 800	1 828 584	97.5	1 121 393
							TOTAL	5 772 363

Note:
* see text for derivation of this number

is calculated from the product of the cross-sectional area and surface length, i.e., 2312.6 x 1050 = 2 428 230 m^3. Using a density of 2.18 tonnes/m^3, there are 5 293 540 tonnes of oil shale. At an average yield of 93.4 L/tonne there are 3 109 790 barrels of shale oil in place in Block 1.

The above calculation of 3 109 790 barrels is a maximum reserve for bed Ma_s. The bed on the southern limb of the Frederick Brook anticline in Block 1 dips to the south and is displaced in the subsurface by the Gesner Fault and the northern part of the Wright Fault. For this reason the bed does not extend to a depth of 100 m in most places along the north side of the faults (see cross-section A-A', B-B', and C-C' on Plate 87-62(R)). Therefore the actual quantity of oil shale in bed Ma_s in Block 1 is perhaps ten per cent less than 3 109 790 barrels. A more realistic in-place reserve estimate for Block 1 would be about 2 800 000 barrels (Table 6).

The method of reserve calculation for Block 1 has been applied to Block 2 - the location of the latter block being described on page 16. Bed Ma_s in Block 2 is assumed to have an average dip of 75° and a surface strike length of 600 m. In this block, the bed has been intersected in Government of Canada boreholes 55, 57, 58, 74, 75, and 83, Atlantic Richfield Company hole ARCO IA, and Canadian Occidental hole COXY 2 (Plate 87-62(R)). The eight holes give an average yield of 93.2 litres/tonne (Table 6). For the purpose of calculating the average bed thickness, the data from Canadian Occidental Petroleum hole COXY 2 have been omitted. The anomalously large thickness of 44.8 m (Table 5) in this hole is believed to result from its location on the nose of a mesoscopic fold (Plate 87-62(R)). Bed Ma_s in Block 2 accordingly has an average thickness of 23.32 m (Table 6). Using the above assumptions and calculations, there are 1 850 970 barrels of shale oil in place in this block.

In Block 3, a complete section through bed Ma_s is present in eight holes: Government of Canada

holes 41, 42, 48, 59, 78, and 79, and Canadian Occidental Petroleum holes COXY 1 and COXY 5 (Plate 87-62(R)). The bed has an average thickness of 19.71 m and an aggregate surface strike length for its two parts, north and south of the Gesner Fault, of 400 m (Plate 87-62(R) and Table 6). With an average yield of 97.5 litres/tonne, the bed contains an *in situ* shale oil reserve of 1 121 393 barrels (Table 6).

The above assessment indicates that to a depth of 100 m, the organic-rich oil shale bed Ma_s in Blocks 1, 2, and 3 at Albert Mines has an estimated in-place shale oil content of about 5.8 million barrels (Table 6). It is obvious that the reserves can be greatly increased by extending the mining depth to 500 m. In this regard it should be noted that below 100 m, bed Ma_s in Block 1 is only present on the west-dipping limb of the Frederick Brook anticline. If it is assumed that bed Ma_s retains a constant down-dip thickness and grade in all three blocks, it can be shown that to a depth of 500 m there is an in-place reserve of about 22 000 000 barrels of shale oil.

In contrast to the sections at Rosevale and Dover, the Albert Formation at Albert Mines contains several moderate to highly kerogenous (75 to 100 L/tonne) oil shale beds (Wright 1922; Alcock 1948; Macauley and Ball 1982). The beds occur within facies Ma_f and lie both above and below the thick Ma_s bed. These beds are 3 to 8 m in thickness and if they were selectively recovered during the mining of bed Ma_s they would more than double the *in situ* reserves. In addition to this, the average organic content of the shales and siltstones that lie between the highly kerogenous beds is higher than at other known sites in the Moncton Subbasin. For example, the average Fischer Assay yield is 59 L/tonne for beds from the surface to a depth of 93 m in Government of Canada hole 53 (Plate 87-62(R)).

The content of calcium or the quantity of carbonate minerals within the Albert Mines shales was not assessed during past drill-core assay studies. It was not until the advent of research demonstrating that sulphur oxide gases generated from coal combustion could be captured by oil shale calcium, that the need for such assays arose (Gilders and Salter 1981; Boorman *et al.* 1982; Salib *et al.* 1984). Five core samples of bed Ma_s from Canadian Occidental Petroleum hole COXY 5 were analysed for CaO content by Smith (1985). The samples were chosen at depths of 198.12 m, 215.49 m, 219.46 m, 249.02 m, and 266.10 m. They were analysed by atomic absorption spectrophotometry (AA) and give an average CaO content of 19.5% (wt.). This is equivalent to a total calcium content of 13.9%. X-ray diffraction analyses of the samples (Smith 1985) give calcite to dolomite ratios of 1:1.5 (198.12 m), 6:1 (215.49 m), 1:4 (219.46 m), 1:65 (249.02 m), and 4.25:1 (266.10 m). The actual calcium "available" for reaction with sulphur oxide gases would be somewhat less than the 13.9%. Some of the calcium is present in plagioclase feldspar and lesser amounts in amphiboles, etc. (Macauley and Ball 1982).

In 1986, Canadian Occidental Petroleum Ltd. excavated 9000 tonnes of oil shale from the Albert Mines area. About 8650 tonnes of this were removed, crushed, and stockpiled from the oil shale test pit shown on Plate 87-62(R). The remaining 350 tonnes were removed from a second small pit at the site of the trench in the high-grade bed

Ma_s, 60 m east of Frederick Brook (Plate 87-62(R)). Fifty-five channel and grab samples were taken from the larger test pit and 17 samples were taken from the test pit stockpiles. The shales in the test pit have an average dip of 25° and the analysed samples represent a stratigraphic thickness of about 20 to 25 m. The samples were analysed for calcium content by atomic absorption spectrophotometry (AA) after being partially digested by hot 50% hydrochloric acid. The 55 test pit samples show an average available calcium content of 5.29%. The stockpile samples are in close agreement and give a yield of 5.17%.

Three grab samples and a stockpile sample from the organic-rich bed Ma_s in the second pit show an average calcium content of 7.81% (Ball 1987). The organic-rich bed Ma_s contains substantially more available calcium than the organically leaner shales. The same conclusion can be drawn from the high calcium values in bed Ma_s in the COXY 5 hole described above (Smith 1985).

In summary, it can be stated that the oil shales at Albert Mines are a very encouraging prospect for development. In the most organic-rich bed, there is an estimated 5.8 million barrels of shale oil in place to a depth of 100 m. Limited assay data suggest that this bed may contain nearly 8% available calcium.

CONCLUSIONS

The oil shales of southeastern New Brunswick were assessed to determine their oil yield and calcium content. The available calcium content provides an indication of the potential of the shale to neutralize sulphur oxide gases when cocombusted with high-sulphur coal. An appraisal of past geological mapping studies, subsurface drilling results, and analytical data indicates that the oil shales at three sites - Rosevale, Dover, and Albert Mines - contain sufficient organic matter and calcium to warrant detailed assessment. There are several other sites in the Moncton Subbasin where organic-rich shales are exposed at the surface. However, it is not possible with the presently limited data to evaluate them properly. A summary of the oil shale resources at Rosevale, Dover, and Albert Mines is given in Table 7.

At Rosevale, four drill holes in the Bray Brook zone indicate that a 14 m thick bed of oil shale contains an in-place shale oil reserve of over 2.5 million barrels to a depth of 100 m. The Bray Brook zone is the only oil shale in New Brunswick that has been systematically evaluated for carbonate minerals content (Brown and Whaley 1986). One hundred twenty-two assays from the four drill-hole intersections give average calcium values of 11.3% (wt.), 13.1% (wt.), 10.1% (wt.), and 8.9% (wt.), indicating that there are about 460 000 tonnes of calcium in place (Table 7).

The Boyd Creek oil shale bed at Dover is about 11.2 m thick and has a strike length of over 2 km. The two holes drilled into the bed give an average Fischer Assay shale oil yield of 97.9 L/tonne. The bed has an estimated in situ oil reserve of approximately 8.4 million barrels to a depth of 100 m. Four randomly selected grab samples from one of the core intervals suggest that the bed may have a calcium content as high as 12% by weight. More data are needed to substantiate this figure.

The Boyd Creek bed dips shallowly and consequently the stripping ratio for a surface mine would be

TABLE 7

SUMMARY OF SHALE OIL AND CALCIUM RESERVE ESTIMATES OF ORGANIC-RICH OIL SHALE BEDS TO A DEPTH OF 100 M AT ROSEVALE, DOVER, AND ALBERT MINES, NEW BRUNSWICK

AREA	THICKNESS (m)	AVG. YIELD (L/tonne)	WEIGHT (tonnes)	OIL RESERVE (bbl.)	CALCIUM (tonnes)
ROSEVALE	14.2	102.4	3 992 578	2 542 310	462 671
DOVER	11.2	97.9	13 962 856	8 419 753	------
ALBERT MINES	19.8	94.7	10 279 611	5 772 363	802 838

relatively low.

Just to the north of the Boyd Creek bed, there are two oil shale beds that warrant further exploration. In summary, the Dover oil shale area has encouraging potential for development.

The oil shales at Albert Mines have been evaluated several times during this century (Ells 1903, 1909; Wright 1922; Alcock 1948; Worth 1975; Macauley and Ball 1982). Of the forty-seven drill holes in the area, twenty-eight intersect an organic-rich oil shale bed that averages 19.8 m in thickness (Table 7). The bed has an average yield of 94.7 L/tonne and an estimated in-place shale oil reserve to a depth of 100 m of nearly 5.8 million barrels. Limited calcium oxide analyses suggest a potential calcium reserve of about 800 000 tonnes. Several thinner organic-rich oil shale strata above and below the thick bed would greatly increase the in-place shale oil and calcium reserves at Albert Mines. Of the three sites evaluated, the shale oil reserves at Albert Mines are considered the most reliable because of the larger analytical data base.

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APPENDIX I

DRILL-CORE ASSAY DATA FOR THE ROSEVALE OIL SHALE AREA

ROSEVALE NO.1 (RV-1) ASSAY DATA

ELEVATION: 251 m
LENGTH: 162.2 m
INCLINATION: -60°
AZIMUTH: 170°(True)

SAMPLE INTERVAL m		LENGTH m	OIL, CALCULATED L/tonne	CARBONATE CARBON(wt.%)	CA EQUIV. wt.%
117.40	118.00	.60	54.26	3.11	10.37
118.00	118.60	.60	68.78	2.77	9.23
118.60	119.20	.60	68.65	2.01	6.70
119.20	119.80	.60	142.43	2.28	7.60
119.80	120.40	.60	49.68	5.73	19.10
120.40	121.00	.60	80.58	2.48	8.27
121.00	121.60	.60	34.86	3.69	12.30
121.60	122.20	.60	107.27	4.19	14.00
122.20	122.80	.60	141.79	2.08	6.93
122.80	123.40	.60	123.72	3.94	13.13
123.40	124.00	.60	101.17	3.08	10.27
124.00	124.60	.60	96.50	1.68	5.60
124.60	125.20	.60	98.81	1.86	6.20
125.20	125.80	.60	20.48	2.69	8.97
125.80	126.40	.60	13.53	2.21	7.37
126.40	127.00	.60	17.39	2.12	7.07
127.00	127.60	.60	120.85	2.33	7.77
127.60	128.20	.60	149.74	2.41	8.03
128.20	128.80	.60	87.09	3.68	12.27
128.80	129.40	.60	141.39	2.63	8.77
129.40	130.00	.60	84.81	2.46	8.20
130.00	130.60	.60	113.53	3.38	11.27
130.60	131.20	.60	130.20	3.28	10.93
131.20	131.80	.60	88.40	3.82	12.73
131.80	132.40	.60	133.57	4.18	13.93
132.40	133.00	.60	207.93	1.80	6.00
133.00	133.60	.60	88.10	3.52	11.73
133.60	134.20	.60	93.78	4.19	13.97
134.20	134.80	.60	76.45	4.89	16.30
134.80	135.40	.60	56.37	3.75	12.50
135.40	136.00	.60	77.88	6.07	20.23
136.00	136.60	.60	90.88	4.69	15.63
136.60	137.20	.60	116.57	4.89	16.30
137.20	137.80	.60	125.10	4.43	14.77
137.80	138.40	.60	117.59	3.29	10.97
138.40	139.00	.60	91.18	3.01	10.03
139.00	139.60	.60	16.70	3.37	11.23
139.60	140.20	.60	56.52	3.58	11.93

ROSEVALE NO.1 (RV-1) ASSAY DATA (continued)

SAMPLE INTERVAL m		LENGTH m	OIL, CALCULATED L/tonne	CARBONATE CARBON(wt.%)	CA EQUIV. wt.%
140.20	140.80	.60	77.95	4.31	14.37
140.80	141.40	.60	84.91	4.08	13.60
141.40	142.00	.60	71.49	3.04	10.13
142.00	142.60	.60	62.09	3.36	11.20
142.60	143.20	.60	121.05	4.80	16.00
143.20	143.80	.60	83.69	4.08	13.60
143.80	144.40	.60	113.37	2.81	9.37
144.40	145.00	.60	84.12	1.79	5.97
145.00	145.60	.60	120.43	2.46	8.20
145.60	146.20	.60	36.20	4.32	14.40
146.20	146.80	.60	16.13	10.35	34.50
146.80	147.40	.60	35.55	5.31	17.70
147.40	148.00	.60	53.19	4.20	14.00
148.00	148.60	.60	25.40	3.24	10.80
148.60	149.20	.60	60.90	3.00	10.00
149.20	149.80	.60	95.51	2.02	6.73
149.80	150.40	.60	124.13	3.25	10.83
150.40	151.00	.60	68.85	2.73	9.10
151.00	151.60	.60	160.20	3.83	12.77
151.60	152.20	.60	203.51	2.44	8.13
152.20	152.80	.60	139.05	2.27	7.57
152.80	153.40	.60	89.43	3.43	11.43
153.40	154.00	.60	93.63	1.49	4.97
154.00	154.60	.60	110.94	3.20	10.67
154.60	155.20	.60	47.69	2.54	8.47
			AVG. 86.28	3.40	11.32

ROSEVALE NO.2 (RV-1) ASSAY DATA

ELEVATION: 235 m
LENGTH: 108.0 m

INCLINATION: -45°
AZIMUTH: 170°(True)

SAMPLE INTERVAL m		LENGTH m	OIL, CALCULATED L/tonne	CARBONATE CARBON(wt.%)	CA EQUIV. wt.%
56.00	56.60	.60	38.67	3.63	12.10
56.60	57.20	.60	57.41	2.70	9.00
57.20	57.80	.60	83.45	4.74	15.80
57.80	58.40	.60	78.85	3.35	11.17
58.40	59.00	.60	33.35	4.09	13.63
59.00	59.60	.60	16.41	2.93	9.77
59.60	60.20	.60	32.12	3.33	11.10
60.20	60.80	.60	111.90	2.68	8.92
60.80	61.40	.60	166.30	4.28	14.27
61.40	62.00	.60	198.78	4.64	15.47
62.00	62.60	.60	131.02	7.85	26.16
62.60	63.20	.60	163.77	4.75	15.83
63.20	63.80	.60	164.04	5.65	18.83
63.80	64.40	.60	165.79	5.89	19.63
64.40	65.00	.60	163.80	6.54	21.80
65.00	65.60	.60	141.48	4.76	15.87
65.60	66.20	.60	134.20	4.52	15.07
66.20	66.80	.60	103.12	5.99	19.96
66.80	67.40	.60	145.71	4.66	15.53
67.40	68.00	.60	121.44	1.89	6.30
68.00	68.60	.60	119.74	1.71	5.70
68.60	69.20	.60	104.77	2.13	7.10
69.20	69.80	.60	53.96	1.77	5.90
69.80	70.40	.60	165.31	4.28	14.27
70.40	71.00	.60	26.95	2.27	7.57
71.00	71.60	.60	168.51	4.84	16.13
71.60	72.20	.60	70.09	2.72	9.07
72.20	72.80	.60	26.93	2.48	8.27
72.80	73.40	.60	49.75	2.97	9.90
73.40	74.00	.60	57.59	3.04	10.13
74.00	74.60	.60	76.91	4.24	14.13
			AVG. 102.30	3.91	13.05

ROSEVALE NO.4 (RV-4) ASSAY DATA

ELEVATION: 233 m
LENGTH: 151.5 m
INCLINATION: -60°
AZIMUTH: 210°(True)

SAMPLE INTERVAL m		LENGTH m	OIL, CALCULATED L/tonne	CARBONATE CARBON(wt.%)	CA EQUIV. wt.%
47.40	48.00	.60	92.06	1.91	6.37
48.00	48.60	.60	35.66	2.42	8.07
48.60	49.20	.60	73.13	1.69	5.63
49.20	49.80	.60	108.42	3.12	10.40
49.80	50.40	.60	54.58	5.63	18.76
50.40	51.00	.60	92.26	3.95	13.17
51.00	51.60	.60	69.98	2.41	8.03
51.60	52.20	.60	86.71	1.90	6.33
52.20	52.80	.60	213.10	4.00	13.33
52.80	53.40	.60	99.17	3.35	11.17
53.40	54.00	.60	189.55	2.80	9.33
54.00	54.60	.60	114.83	2.42	8.07
54.60	55.20	.60	167.29	1.90	6.33
55.20	55.80	.60	79.00	3.27	10.90
55.80	56.40	.60	167.24	2.70	9.00
56.40	57.00	.60	181.36	4.47	14.90
57.00	57.60	.60	174.57	6.16	20.53
57.60	58.20	.60	129.51	1.79	5.97
58.20	58.80	.60	170.42	2.45	8.17
58.80	59.40	.60	167.71	2.46	8.20
59.40	60.00	.60	166.75	2.73	9.10
60.00	60.60	.60	143.73	2.94	9.80
			AVG. 126.23	3.02	10.07

ROSEVALE NO.6 (RV-6) ASSAY DATA

ELEVATION: 245 m
LENGTH: 102.7 m

INCLINATION: -60°
AZIMUTH: 170°(True)

SAMPLE INTERVAL m		LENGTH m	OIL, CALCULATED L/tonne	CARBONATE CARBON(wt.%)	CA EQUIV. wt.%
68.60	69.20	.60	50.14	1.83	6.10
69.20	69.80	.60	120.81	2.31	7.70
69.80	70.40	.60	113.09	.58	1.93
70.40	71.00	.60	123.63	3.49	11.63
71.00	71.60	.60	104.17	4.97	16.57
71.60	72.20	.60	56.66	2.88	9.60
			AVG. 94.97	2.68	8.92

APPENDIX II

DRILL-CORE ASSAY DATA FOR THE DOVER OIL SHALE AREA

PETRO-CANADA DOVER NO. 2 (PCAN-2) ASSAY DATA

ELEVATION: 44.6 m
LENGTH: 379.97 m

INCLINATION: -90°
AZIMUTH: ------

SAMPLE INTERVAL* m	LENGTH m	OIL, FISCHER ASSAY L/tonne
116.40 - 117.90	1.50	78.2
117.90 - 119.40	1.50	73.2
119.40 - 120.90	1.50	90.4
120.90 - 122.40	1.50	75.2
122.40 - 123.90	1.50	63.4
123.90 - 125.40	1.50	124.1
125.40 - 126.90	1.50	103.9
126.90 - 128.46	1.56	101.0
		AVG. 88.7

SAMPLE DEPTH+ m	CaO wt.%	Ca EQUIV. wt.%
117.41	8.12	5.80
119.74	22.78	16.27
125.53	24.13	17.24
127.32	12.12	8.66
		AVG. 11.99

*Data from J.Y. Wright 1982
+Data from W.D. Smith 1985

CARTAGO DOVER NO. 1 (CRL-1) ASSAY DATA

ELEVATION: 63 m
LENGTH: 105.77 m

INCLINATION: -90°
AZIMUTH: ------

SAMPLE INTERVAL m	LENGTH m	OIL, CALCULATED L/tonne
69.34 - 70.26	0.92	96.47
70.26 - 71.17	0.91	90.83
71.17 - 72.09	0.92	95.86
72.09 - 73.00	0.91	69.23
73.00 - 73.91	0.91	156.74
73.91 - 74.83	0.92	88.45
74.83 - 75.74	0.91	130.08
75.74 - 76.66	0.92	110.42
76.66 - 77.57	0.91	74.96
77.57 - 78.49	0.92	108.13
78.49 - 79.40	0.91	130.54
79.40 - 80.31	0.91	106.19
80.31 - 81.23	0.92	127.83
81.23 - 82.14	0.91	114.12
		AVG. 107.13

APPENDIX III

DRILL-CORE ASSAY DATA FOR THE ALBERT MINES OIL SHALE AREA

GOVERNMENT OF CANADA ALBERT MINES NO.38 ASSAY DATA

ELEVATION: 107.3 m
LENGTH: 122.0 m

INCLINATION: -45°
AZIMUTH: 107°(True)

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
19.21 - 20.73	1.52	131.5
20.73 - 22.26	1.53	127.0
22.26 - 23.78	1.52	98.5
23.78 - 25.30	1.52	120.0
25.30 - 26.83	1.53	109.5
26.83 - 28.05	1.52	84.5
28.05 - 29.57	1.52	97.0
29.57 - 31.10	1.53	88.5
31.10 - 32.32	1.22	84.5
32.32 - 33.23	.91	-
33.23 - 33.54	.31	74.0
33.54 - 35.37	1.83	77.0
35.37 - 36.89	1.52	208.0
36.89 - 38.41	1.52	128.5
38.41 - 39.94	1.53	94.0
39.94 - 41.46	1.52	163.0
41.46 - 42.99	1.53	123.0
42.99 - 44.51	1.52	70.0
44.51 - 46.04	1.53	85.5
46.04 - 47.56	1.52	77.0
47.56 - 49.09	1.53	85.5
49.09 - 50.61	1.52	85.5
50.61 - 52.13	1.52	117.0
52.13 - 53.35	1.22	83.0
53.35 - 54.88	1.53	128.5
54.88 - 56.40	1.52	136.0
56.40 - 57.92	1.52	164.5
57.92 - 59.45	1.53	108.0
59.45 - 60.98	1.53	133.0
60.98 - 62.50	1.52	112.5
62.50 - 64.02	1.52	143.0
64.02 - 65.55	1.53	136.0
65.55 - 67.07	1.52	108.5
67.07 - 68.60	1.53	120.0
		AVG. 112.2

GOVERNMENT OF CANADA ALBERT MINES NO.40 ASSAY DATA

ELEVATION: 112.8 m
LENGTH: 122.3 m

INCLINATION: -45°
AZIMUTH: 127°(True)

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
21.95 - 23.48	1.53	68.5
23.48 - 25.00	1.52	65.5
25.00 - 26.52	1.52	57.0
26.52 - 28.05	1.53	65.5
28.05 - 29.57	1.52	65.5
29.57 - 31.10	1.53	83.0
31.10 - 32.32	1.22	60.0
32.32 - 33.84	1.52	134.0
33.84 - 35.37	1.53	94.0
35.37 - 36.89	1.52	123.0
36.89 - 38.41	1.52	154.0
38.41 - 39.94	1.53	134.0
39.94 - 41.46	1.52	77.0
		AVG. 90.8

GOVERNMENT OF CANADA ALBERT MINES NO.41 ASSAY DATA

ELEVATION: 112.2 m
LENGTH: 53.4 m
INCLINATION: -45°
AZIMUTH: 321°(True)

SAMPLE INTERVAL	LENGTH	OIL, FISCHER ASSAY
m	m	L/tonne
10.67 - 12.20	1.53	70.0
12.20 - 13.72	1.52	90.0
13.72 - 15.24	1.52	75.5
15.24 - 16.77	1.53	108.5
16.77 - 18.29	1.52	80.0
18.29 - 20.12	1.83	81.5
20.12 - 21.34	1.22	71.5
21.34 - 22.87	1.53	107.5
22.87 - 24.39	1.52	71.5
24.39 - 25.91	1.52	128.5
25.91 - 27.44	1.53	137.0
27.44 - 29.54	2.10	120.0
29.54 - 30.49	.95	77.0
30.49 - 32.01	1.52	134.0
32.01 - 33.54	1.53	110.0
33.54 - 35.06	1.52	74.0
35.06 - 36.59	1.53	68.6
36.59 - 38.11	1.52	60.0
		AVG. 92.5

GOVERNMENT OF CANADA ALBERT MINES NO.42 ASSAY DATA

ELEVATION: 123.5 m
LENGTH: 132.6 m

INCLINATION: -45°
AZIMUTH: 322°(True)

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
84.45 - 86.89	2.44	77.0
86.89 - 88.41	1.52	57.0
88.41 - 89.94	1.53	68.5
89.94 - 91.46	1.52	114.0
91.46 - 92.99	1.53	84.5
92.99 - 94.51	1.52	95.5
94.51 - 96.04	1.53	92.5
96.04 - 97.26	1.22	87.7
97.26 - 97.87	.61	83.0
97.87 - 99.09	1.22	78.5
99.09 - 100.61	1.52	111.0
100.61 - 102.13	1.52	97.0
102.13 - 103.66	1.53	114.0
103.66 - 105.18	1.52	91.0
105.18 - 106.71	1.53	63.0
		AVG. 87.6

GOVERNMENT OF CANADA ALBERT MINES NO.47 ASSAY DATA

ELEVATION: 104.0 m
LENGTH: 76.2 m

INCLINATION: -50°
AZIMUTH: 317°(True)

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
0 - 7.93	7.93	Casing
7.93 - 9.15	1.22	128.5
9.15 - 10.67	1.52	111.0
10.67 - 12.20	1.53	100.0
12.20 - 13.72	1.52	123.0
13.72 - 15.24	1.52	94.0
15.24 - 16.92	1.68	71.5
16.92 - 18.29	1.37	57.0
		AVG. 97.9

GOVERNMENT OF CANADA ALBERT MINES NO.48 ASSAY DATA

ELEVATION: 103.7 m
LENGTH: 76.2 m

INCLINATION: -50°
AZIMUTH: 312°(True)

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
8.63 - 9.15	.52	80.0
9.15 - 10.67	1.52	91.0
10.67 - 12.20	1.53	111.0
12.20 - 13.72	1.52	108.5
13.72 - 15.24	1.52	83.0
15.24 - 16.77	1.53	74.5
16.77 - 18.29	1.52	91.5
18.29 - 19.82	1.53	66.0
19.82 - 21.34	1.52	60.0
21.34 - 22.87	1.53	114.0
22.87 - 25.91	3.04	114.0
25.91 - 27.44	1.53	106.0
27.44 - 28.96	1.52	128.5
28.96 - 30.49	1.53	77.0
30.49 - 32.01	1.52	125.5
32.01 - 33.54	1.53	107.5
		AVG. 97.2

GOVERNMENT OF CANADA ALBERT MINES NO.51 ASSAY DATA

ELEVATION: 85.7 m
LENGTH: 76.2 m

INCLINATION: -55°
AZIMUTH: 009°(True)

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
26.19 - 26.83	.63	115.0
26.83 - 28.35	1.52	79.5
28.35 - 29.57	1.22	147.5
29.57 - 31.10	1.53	141.0
31.10 - 32.62	1.52	84.0
32.62 - 34.15	1.53	99.0
34.15 - 35.67	1.52	114.0
35.67 - 37.20	1.53	90.0
37.20 - 38.41	1.21	49.0
38.41 - 41.46	3.05	90.0
41.46 - 42.99	1.53	50.0
42.99 - 44.70	1.71	64.5
44.70 - 46.04	1.36	63.0
46.04 - 47.56	1.52	87.0
47.56 - 49.09	1.53	123.0
49.09 - 50.61	1.52	153.0
50.61 - 52.13	1.52	117.0
52.13 - 53.66	1.53	99.0
53.66 - 55.18	1.52	141.0
		AVG. 99.8

GOVERNMENT OF CANADA ALBERT MINES NO.52 ASSAY DATA

ELEVATION: 84.1 m
LENGTH: 152.4 m

INCLINATION: -60°
AZIMUTH: 004°(True)

SAMPLE INTERVAL* m	LENGTH m	OIL, FISCHER ASSAY L/tonne
0 - 2.13	2.13	81.0
2.13 - 3.05	0.92	123.0
3.05 - 4.57	1.52	87.0
4.57 - 6.10	1.53	75.0
6.10 - 7.62	1.52	162.0
7.62 - 9.15	1.53	132.0
9.15 - 10.67	1.52	147.0
10.67 - 12.20	1.53	121.0
12.20 - 13.72	1.52	90.0
13.72 - 15.24	1.52	60.0
		AVG. 107.8

*Bed Ma_s was imcompletely intersected; the hole was spudded in the bed (see Plate 87-62(R)).

GOVERNMENT OF CANADA ALBERT MINES NO.55 ASSAY DATA

ELEVATION: 100.0 m
LENGTH: 122.9 m

INCLINATION: -45°
AZIMUTH: 352°(True)

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
15.24 - 16.77	1.53	80.0
16.77 - 18.29	1.52	65.5
18.29 - 19.82	1.53	57.0
19.82 - 21.34	1.52	65.5
21.34 - 22.87	1.53	88.5
22.87 - 24.39	1.52	71.5
24.39 - 25.91	1.52	77.0
25.91 - 27.44	1.53	51.5
27.44 - 28.96	1.52	60.0
28.96 - 30.49	1.53	57.0
30.49 - 32.01	1.52	60.0
32.01 - 33.54	1.53	126.0
33.54 - 34.60	1.06	88.5
34.60 - 35.98	1.38	65.5
35.98 - 38.11	2.13	71.5
38.11 - 39.63	1.52	106.0
39.63 - 41.16	1.53	63.0
41.16 - 42.68	1.52	123.0
42.68 - 44.21	1.53	128.5
44.21 - 45.73	1.52	114.0
45.73 - 47.26	1.53	74.0
47.26 - 48.78	1.52	97.0
48.78 - 50.30	1.52	94.0
50.30 - 51.83	1.53	41.0
51.83 - 53.35	1.52	86.0
53.35 - 54.88	1.53	51.5
54.88 - 56.40	1.52	60.0
56.40 - 57.93	1.53	43.0
57.93 - 59.45	1.52	40.0
59.45 - 60.98	1.53	34.5
60.98 - 62.50	1.52	77.0
62.50 - 64.02	1.52	77.0
64.02 - 65.95	1.53	86.0
65.55 - 67.07	1.52	97.0
67.07 - 68.60	1.53	54.0
68.60 - 70.12	1.52	71.5
70.12 - 71.64	1.52	97.0
71.64 - 73.17	1.53	108.5
73.17 - 74.70	1.53	83.0
		AVG. 76.7

GOVERNMENT OF CANADA ALBERT MINES NO.56 ASSAY DATA

ELEVATION: 122.3 m
LENGTH: 306.4 m

INCLINATION: -45°
AZIMUTH: 112°(True)

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
175.61 - 177.13	1.52	97.0
177.13 - 178.66	1.52	97.0
178.66 - 180.18	1.52	61.5
180.18 - 181.71	1.53	43.0
181.71 - 183.23	1.52	28.5
183.23 - 184.76	1.53	45.5
184.76 - 185.98	1.22	86.0
185.98 - 187.50	1.52	123.0
187.50 - 189.02	1.52	123.0
189.02 - 190.55	1.53	86.0
		AVG. 79.1

GOVERNMENT OF CANADA ALBERT MINES NO.57 ASSAY DATA

ELEVATION: 100.0 m
LENGTH: 122.0 m

INCLINATION: -90°
AZIMUTH: --------

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
12.20 - 13.72	1.52	100.0
13.72 - 15.24	1.52	57.0
15.24 - 16.77	1.53	151.5
16.77 - 18.29	1.52	111.5
18.29 - 19.82	1.53	108.5
19.82 - 21.34	1.52	83.0
21.34 - 22.87	1.53	71.5
22.87 - 24.39	1.52	65.5
24.39 - 25.91	1.52	77.0
25.91 - 27.44	1.53	103.0
27.44 - 28.96	1.52	57.0
28.96 - 30.49	1.53	134.5
30.49 - 32.01	1.52	114.0
32.01 - 33.54	1.53	97.0
33.54 - 35.06	1.52	137.5
35.06 - 36.59	1.53	111.5
36.59 - 38.11	1.52	100.0
38.11 - 39.63	1.52	100.0
39.63 - 41.16	1.53	51.5
41.16 - 42.68	1.52	88.5
42.68 - 44.21	1.53	176.5
44.21 - 45.73	1.52	134.5
45.73 - 47.26	1.53	31.5
47.26 - 48.78	1.52	63.0
48.78 - 50.30	1.52	111.5
50.30 - 51.83	1.53	120.0
51.83 - 53.35	1.52	156.5
53.35 - 54.88	1.53	83.0
54.88 - 56.40	1.52	140.0
56.40 - 57.93	1.53	154.5
57.93 - 59.45	1.52	134.5
59.45 - 60.98	1.53	120.0
60.98 - 62.50	1.52	57.0
62.50 - 64.02	1.52	80.0
64.02 - 65.55	1.53	68.5
65.55 - 67.07	1.52	51.5
67.07 - 68.60	1.53	51.5
68.60 - 70.12	1.52	74.0

GOVERNMENT OF CANADA ALBERT MINES NO.57 ASSAY DATA (continued)

SAMPLE INTERVAL	LENGTH	OIL, FISCHER ASSAY
m	m	L/tonne
70.12 - 71.65	1.53	108.5
71.65 - 73.17	1.52	57.0
73.17 - 74.70	1.53	80.0
74.70 - 76.22	1.52	74.0
76.22 - 77.74	1.52	71.5
77.74 - 79.27	1.53	77.0
79.27 - 80.79	1.52	88.5
		AVG. 95.2

GOVERNMENT OF CANADA ALBERT MINES NO.58 ASSAY DATA

ELEVATION: 88.1 m
LENGTH: 122.0 m

INCLINATION: -45°
AZIMUTH: 017°(True)

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
47.56 - 49.09	1.53	83.0
49.09 - 50.61	1.52	65.5
50.61 - 52.13	1.52	80.0
52.13 - 53.66	1.53	143.0
53.66 - 55.18	1.52	65.5
55.18 - 56.71	1.53	28.5
56.71 - 57.93	1.52	65.5
57.93 - 59.45	1.52	63.0
59.45 - 60.98	1.53	117.0
60.98 - 62.50	1.52	148.5
62.50 - 64.02	1.52	97.0
64.02 - 65.55	1.53	71.5
65.55 - 67.07	1.52	106.0
67.07 - 68.60	1.53	134.5
68.60 - 70.12	1.52	97.0
70.12 - 71.65	1.53	91.5
71.65 - 73.17	1.52	94.0
73.17 - 74.70	1.53	94.0
74.70 - 76.22	1.52	80.0
76.22 - 77.74	1.52	154.5
77.74 - 79.27	1.53	143.0
79.27 - 80.79	1.52	97.0
80.79 - 82.32	1.53	174.5
82.32 - 83.84	1.52	157.5
83.84 - 85.37	1.53	137.5
85.37 - 86.89	1.52	86.0
86.89 - 88.11	1.22	45.0
88.11 - 89.63	1.52	174.0
89.63 - 91.16	1.53	103.0
		AVG. 103.4

GOVERNMENT OF CANADA ALBERT MINES NO.59 ASSAY DATA

ELEVATION: 109.8 m
LENGTH: 304.9 m

INCLINATION: -45°
AZIMUTH: 322°(True)

SAMPLE INTERVAL* m	LENGTH m	OIL, FISCHER ASSAY L/tonne
25.91 - 27.44	1.53	103.0
27.44 - 28.96	1.52	60.0
28.96 - 30.49	1.53	146.0
30.49 - 32.01	1.52	89.5
32.01 - 33.54	1.53	114.0
33.54 - 35.06	1.52	111.5
35.06 - 36.59	1.53	177.5
36.59 - 38.11	1.52	146.0
38.11 - 39.63	1.52	57.0
39.63 - 41.16	1.53	77.0
		AVG. 108.2

89.94 - 91.46	1.52	83.0
91.46 - 92.99	1.53	91.5
92.99 - 94.51	1.52	86.0
94.51 - 96.04	1.53	63.0
96.04 - 97.56	1.52	65.5
97.56 - 99.09	1.53	65.5
		AVG. 75.8

*Bed Ma_5 is repeated in this hole by the Wright Fault (see Plate 87-62(R) and accompanying cross-section C-C^1).

GOVERNMENT OF CANADA ALBERT MINES NO.73 ASSAY DATA

ELEVATION: 106.4 m
LENGTH: 120.4 m

INCLINATION: -90°
AZIMUTH: --------

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
44.21 - 45.73	1.52	103.0
45.73 - 47.26	1.53	126.0
47.26 - 48.78	1.52	80.0
48.78 - 50.30	1.52	108.5
50.30 - 51.83	1.53	114.0
51.83 - 53.35	1.52	71.5
53.35 - 54.88	1.53	71.5
54.88 - 56.40	1.52	100.0
56.40 - 57.93	1.53	131.5
57.93 - 59.45	1.52	63.0
59.45 - 60.98	1.53	45.5
60.98 - 62.50	1.52	77.0
62.50 - 64.02	1.52	45.5
64.02 - 65.54	1.52	74.0
65.54 - 67.07	1.53	177.5
67.07 - 68.60	1.53	111.5
68.60 - 70.12	1.52	108.5
70.12 - 71.65	1.53	106.0
71.65 - 73.17	1.52	123.0
73.17 - 74.70	1.53	83.0
74.70 - 76.22	1.52	51.5
76.22 - 77.74	1.52	71.5
77.74 - 79.27	1.53	111.5
79.27 - 80.79	1.52	134.5
80.79 - 82.32	1.53	114.0
82.32 - 83.84	1.52	100.0
		AVG. 96.3

GOVERNMENT OF CANADA ALBERT MINES NO.74 ASSAY DATA

ELEVATION: 86.9 m
LENGTH: 110.4 m

INCLINATION: -90°
AZIMUTH: --------

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
53.35 - 54.88	1.52	77.0
54.88 - 56.40	1.52	83.0
56.40 - 57.93	1.53	100.0
57.93 - 59.45	1.52	40.0
59.45 - 60.98	1.53	105.5
60.98 - 62.50	1.52	126.0
62.50 - 64.02	1.52	108.5
64.02 - 65.54	1.52	120.0
65.54 - 67.07	1.53	80.0
67.07 - 68.60	1.53	114.0
68.60 - 70.12	1.52	63.0
70.12 - 71.65	1.53	51.5
71.65 - 73.17	1.52	48.5
73.17 - 74.70	1.53	91.5
74.70 - 76.22	1.52	74.0
76.22 - 77.74	1.52	28.5
77.74 - 79.27	1.53	97.0
79.27 - 80.79	1.52	80.0
80.79 - 82.32	1.53	83.0
82.32 - 83.84	1.52	40.0
83.84 - 85.37	1.53	126.0
85.37 - 86.89	1.52	94.0
86.89 - 88.41	1.52	111.5
		AVG. 84.5

GOVERNMENT OF CANADA ALBERT MINES NO.75 ASSAY DATA

ELEVATION: 88.1 m
LENGTH: 152.1 m

DECLINATION: -90°
AZIMUTH: --------

SAMPLE INTERVAL	LENGTH	OIL, FISCHER ASSAY
m	m	L/tonne

GOVERNMENT OF CANADA ALBERT MINES NO.75 ASSAY DATA

ELEVATION: 88.1 m
LENGTH: 152.1 m

INCLINATION: -90°
AZIMUTH: --------

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
102.13 - 103.66	1.53	128.5
103.66 -105.18	1.52	108.5
105.18 - 106.71	1.53	65.5
106.71 - 108.23	1.52	100.0
108.23 - 109.76	1.53	77.0
109.76 - 111.28	1.52	128.5
111.28 - 112.80	1.52	91.5
112.80 - 114.33	1.53	63.0
114.33 - 115.85	1.52	77.0
115.85 - 177.38	1.53	77.0
117.38 - 118.90	1.52	77.0
118.90 - 120.43	1.53	86.0
		AVG. 90.0

GOVERNMENT OF CANADA ALBERT MINES NO.77 ASSAY DATA

ELEVATION: 95.7 m
LENGTH: 106.7 m

INCLINATION: -90°
AZIMUTH: --------

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
31.10 - 32.01*	0.91	83.0
32.01 - 33.54	1.53	143.0
33.54 - 35.06	1.52	83.0
35.06 - 36.59	1.53	128.5
36.59 - 38.11	1.52	100.0
38.11 - 39.63	1.52	86.0
		AVG. 103.9

68.60 - 70.12*	1.52	111.5
70.12 - 71.65	1.53	45.5
71.65 - 73.17	1.52	91.5
73.17 - 74.70	1.53	88.5
74.70 - 76.22	1.52	108.5
76.22 - 77.74	1.52	88.5
		AVG. 89.0

*Bed Ma_5 is repeated and incomplete, fault defines the upper contacts of both intervals (see Plate 87-62(R) and accompanying cross-section B-B[1]).

GOVERNMENT OF CANADA ALBERT MINES NO.78 ASSAY DATA

ELEVATION: 100.3 m
LENGTH: 76.5 m

INCLINATION: -45°
AZIMUTH: 321°(True)

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
30.49 - 32.01	1.52	106.0
32.01 - 33.54	1.53	48.5
33.54 - 35.06	1.52	146.0
35.06 - 36.59	1.53	86.0
36.59 - 38.11	1.52	143.0
38.11 - 39.63	1.52	28.5
39.63 - 41.16	1.53	77.0
41.16 - 42.68	1.52	28.5
42.68 - 44.21	1.53	71.5
44.21 - 45.73	1.52	143.0
45.73 - 47.26	1.53	137.5
		AVG. 92.3

GOVERNMENT OF CANADA ALBERT MINES NO.79 ASSAY DATA

ELEVATION: 100.3 m
LENGTH: 91.5 m
INCLINATION: -60°
AZIMUTH: 321°(True)

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
30.49 - 32.01	1.52	103.0
32.01 - 33.54	1.53	63.0
33.54 - 35.06	1.52	126.0
35.06 - 36.59	1.53	88.5
36.59 - 38.11	1.52	83.0
38.11 - 39.63	1.52	57.0
39.63 - 41.16	1.53	51.5
41.16 - 42.68	1.52	80.0
42.68 - 44.21	1.53	94.0
44.21 - 45.73	1.52	83.0
45.73 - 47.26	1.53	80.0
47.26 - 48.78	1.52	88.5
		AVG. 83.1

GOVERNMENT OF CANADA ALBERT MINES NO.81 ASSAY DATA

ELEVATION: 108.8 m
LENGTH: 80.2 m

INCLINATION: -90°
AZIMUTH: --------

SAMPLE INTERVAL* m	LENGTH m	OIL, FISCHER ASSAY L/tonne
0.00 - 7.01	7.01	overburden
7.01 - 7.62	.61	108.5
7.62 - 9.15	1.53	68.5
9.15 - 10.67	1.52	86.0
10.67 - 12.20	1.53	28.5
12.20 - 13.72	1.52	182.5
		AVG. 94.8

*Bed Ma_5 was imcompletely intersected; the hole was spudded in the bed (see Plate 87-62(R)).

GOVERNMENT OF CANADA ALBERT MINES NO.83 ASSAY DATA

ELEVATION: 89.6 m
LENGTH: 101.8 m

INCLINATION: -90°
AZIMUTH: --------

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
36.28 - 37.80	1.52	111.5
37.80 - 39.02	1.22	111.5
39.02 - 40.55	1.53	108.5
40.55 - 42.07	1.52	86.0
42.07 - 43.29	1.22	91.5
43.29 - 44.82	1.53	71.5
44.82 - 46.34	1.52	34.5
46.34 - 47.87	1.53	48.5
47.87 - 49.39	1.52	60.0
49.39 - 50.91	1.52	114.0
50.91 - 52.44	1.53	45.5
52.44 - 53.96	1.52	57.0
53.96 - 55.49	1.53	54.0
55.49 - 57.01	1.52	68.5
57.01 - 58.54	1.53	60.0
58.54 - 60.07	1.53	146.0
60.07 - 61.59	1.52	103.0
61.59 - 63.11	1.52	80.0
63.11 - 64.63	1.52	68.5
64.63 - 65.85	1.22	74.3
65.85 - 67.38	1.53	80.0
67.38 - 68.90	1.52	83.0
68.90 - 70.12	1.52	94.0
70.12 - 71.65	1.53	57.0
71.65 - 73.17	1.52	31.5
73.17 - 74.70	1.53	71.5
74.70 - 76.22	1.52	100.0
76.22 - 77.74	1.52	140.0
77.74 - 79.27	1.53	134.5
79.27 - 80.79	1.52	106.0
80.79 - 82.32	1.53	88.5
82.32 - 83.84	1.53	114.0
83.84 - 85.37	1.53	126.0
85.37 - 86.89	1.52	111.5
86.89 - 88.41	1.52	106.0
		AVG. 86.8

ATLANTIC RICHFIELD COMPANY ALBERT MINES NO.1A ASSAY DATA

ELEVATION: 108.2 m
LENGTH: 515.2 m

INCLINATION: -60°
AZIMUTH: 047°(True)

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
126.22 - 127.44	1.22	92.5
127.44 - 128.66	1.22	90.0
128.66 - 129.89	1.23	111.0
129.89 - 131.10	1.21	76.5
131.10 - 132.32	1.22	137.0
132.32 - 133.54	1.22	132.5
133.54 - 134.76	1.22	159.0
134.76 - 135.98	1.22	120.5
135.98 - 137.20	1.22	152.0
137.20 - 138.41	1.21	174.0
138.41 - 139.63	1.22	137.5
139.63 - 140.85	1.22	80.0
140.85 - 142.07	1.22	7.9
142.07 - 143.29	1.22	132.0
143.29 - 144.51	1.22	97.0
144.51 - 145.73	1.22	93.0
145.73 - 146.95	1.22	90.5
146.95 - 148.17	1.22	93.0
148.17 - 149.39	1.22	167.5
149.39 - 150.61	1.22	145.5
150.61 - 151.83	1.22	151.0
151.83 - 153.05	1.22	201.5
153.05 - 154.27	1.22	207.0
154.27 - 155.49	1.22	108.5
155.49 - 156.71	1.22	59.0
156.71 - 157.93	1.22	73.5
157.93 - 159.15	1.22	137.5
159.15 - 160.37	1.22	152.0
160.37 - 161.59	1.22	196.5
161.59 - 162.80	1.21	133.5
162.80 - 164.02	1.22	130.5
164.02 - 165.24	1.22	113.0
165.24 - 166.46	1.22	144.0
166.46 - 167.68	1.22	126.0
167.68 - 168.90	1.22	115.5
168.90 - 170.12	1.22	147.5
170.12 - 171.34	1.22	91.0
171.34 - 172.56	1.22	109.5

ATLANTIC RICHFIELD COMPANY ALBERT MINES NO.1A ASSAY DATA (continued)

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
172.56 - 173.78	1.22	107.5
173.78 - 175.00	1.22	128.0
175.00 - 176.22	1.22	72.0
176.22 - 177.44	1.22	46.6
177.44 - 178.66	1.22	77.0
178.66 - 179.88	1.22	42.7
179.88 - 181.10	1.22	39.9
181.10 - 182.32	1.22	66.0
182.32 - 183.54	1.22	78.5
183.54 - 184.76	1.22	87.5
184.76 - 185.98	1.22	147.0
185.98 - 187.20	1.22	156.5
187.20 - 188.41	1.21	96.0
188.41 - 189.63	1.22	190.5
189.63 - 190.85	1.22	144.0
190.85 - 192.07	1.22	121.5
192.07 - 193.29	1.22	83.0
193.29 - 194.51	1.22	111.5
		AVG. 115.8

CANADIAN OCCIDENTAL PETROLEUM LIMITED ALBERT MINES NO.1 ASSAY DATA

ELEVATION: 100.0 m
LENGTH: 49.7 m

INCLINATION: -90°
AZIMUTH: ---------

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
10.37 - 11.59	1.22	104.9
11.59 - 12.96	1.37	67.0
12.96 - 16.01	3.05	123.7
16.01 - 17.53	1.52	77.9
17.53 - 17.99	.46	27.1
17.99 - 18.60	.61	52.0
18.60 - 20.12	1.52	57.0
20.12 - 20.73	.61	105.0
20.73 - 22.26	1.53	111.2
22.26 - 23.48	1.22	151.5
23.48 - 24.09	.61	152.4
24.09 - 25.00	.91	68.7
25.00 - 26.37	1.37	102.0
26.37 - 27.74	1.37	134.9
27.74 - 29.27	1.53	122.8
29.27 - 29.88	.61	123.7
29.88 - 30.49	.61	99.9
30.49 - 31.86	1.37	154.9
31.86 - 33.23	1.37	119.9
33.23 - 34.15	.92	92.0
34.15 - 35.37	1.22	94.9
35.37 - 36.28	.91	62.0
36.28 - 37.80	1.52	92.0
37.80 - 39.63	1.83	126.6
39.63 - 40.85	1.22	110.7
40.85 - 42.07	1.22	142.8
42.07 - 43.60	1.53	75.8
43.60 - 45.12	1.52	100.8
		WT.AVG. 105.3

CANADIAN OCCIDENTAL PETROLEUM LIMITED ALBERT MINES NO.2 ASSAY DATA

ELEVATION: 103.7 m
LENGTH: 254.9 m

INCLINATION: -90°
AZIMUTH: ---------

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
88.72 - 89.33	.61	95.8
89.33 - 89.94	.61	135.3
89.94 - 90.55	.61	147.8
90.55 - 91.16	.61	160.0
91.16 - 91.77	.61	141.6
91.77 - 92.38	.61	141.6
92.38 - 92.99	.61	124.9
92.99 - 93.60	.61	99.9
93.60 - 94.21	.61	154.0
94.21 - 94.82	.61	90.8
94.82 - 95.43	.61	102.0
95.43 - 96.04	.61	99.9
96.04 - 96.65	.61	119.8
96.65 - 97.26	.61	136.6
97.26 - 97.87	.61	134.1
97.87 - 98.48	.61	154.0
98.48 - 99.09	.61	120.7
99.09 - 99.70	.61	111.6
99.70 - 100.30	.60	97.8
100.30 - 100.91	.61	137.4
100.91 - 101.52	.61	143.6
101.52 - 102.13	.61	108.2
102.13 - 102.74	.61	49.1
102.74 - 103.35	.61	61.6
103.35 - 103.96	.61	90.8
103.96 - 104.57	.61	87.4
104.57 - 105.18	.61	71.6
105.18 - 105.79	.61	62.5
105.79 - 106.40	.61	58.3
106.40 - 107.01	.61	66.6
107.01 - 107.62	.61	74.9
107.62 - 108.23	.61	91.6
108.23 - 108.84	.61	85.3
108.84 - 109.45	.61	86.6
109.45 - 110.06	.61	89.1
110.06 - 110.67	.61	46.6
110.67 - 111.28	.61	41.6

CANADIAN OCCIDENTAL PETROLEUM LIMITED ALBERT MINES NO.2 ASSAY DATA (continued)

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
111.28 - 111.89	.61	16.7
111.89 - 112.50	.61	4.2
112.50 - 113.11	.61	66.6
113.11 - 113.72	.61	50.0
113.72 - 114.63	.91	50.0
114.63 - 115.24	.61	62.5
115.24 - 115.85	.61	67.4
115.85 - 116.46	.61	72.8
116.46 - 117.07	.61	79.1
117.07 - 117.68	.61	72.9
117.68 - 118.29	.61	95.8
118.29 - 118.90	.61	109.1
118.90 - 119.51	.61	141.6
119.51 - 120.12	.61	179.0
120.12 - 120.73	.61	72.9
120.73 - 121.34	.61	95.8
121.34 - 121.95	.61	99.9
121.95 - 122.26	.31	150.3
122.26 - 122.87	.61	135.3
122.87 - 123.48	.61	143.6
123.48 - 124.09	.61	164.5
124.09 - 124.70	.61	149.8
124.70 - 125.30	.60	154.5
125.30 - 125.91	.61	110.3
125.91 - 126.52	.61	121.2
126.52 - 127.13	.61	127.8
127.13 - 127.74	.61	119.9
127.74 - 128.35	.61	102.8
128.35 - 128.96	.61	131.1
128.96 - 129.57	.61	102.0
129.57 - 130.18	.61	132.4
130.18 - 130.79	.61	89.1
130.79 - 131.40	.61	129.9
131.40 - 132.01	.61	133.2
132.01 - 132.62	.61	129.1
132.62 - 133.23	.61	72.9
133.23 - 133.84	.61	53.3
133.84 - 134.45	.61	164.0

CANADIAN OCCIDENTAL PETROLEUM LIMITED ALBERT MINES NO.2 ASSAY DATA
(continued)

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
134.45 - 135.06	.61	85.3
135.06 - 135.67	.61	93.7
135.67 - 136.28	.61	83.3
136.28 - 136.89	.61	100.3
136.89 - 137.50	.61	110.3
137.50 - 138.11	.61	152.0
138.11 - 138.72	.61	114.1
138.72 - 139.33	.61	88.7
139.33 - 139.94	.61	71.6
139.94 - 140.55	.61	83.3
140.55 - 141.16	.61	85.3
141.16 - 141.77	.61	95.8
141.77 - 142.38	.61	88.3
142.38 - 142.99	.61	93.7
142.99 - 143.60	.61	78.7
143.60 - 144.21	.61	89.1
144.21 - 144.82	.61	110.3
144.82 - 145.43	.61	120.7
145.43 - 146.04	.61	120.7
146.04 - 146.65	.61	124.9
146.65 - 147.26	.61	138.2
147.26 - 147.87	.61	156.1
147.87 - 148.48	.61	92.4
148.48 - 149.18	.70	91.2
149.18 - 149.85	.67	127.4
149.85 - 150.46	.61	127.4
150.46 - 151.13	.67	83.3
151.13 - 151.83	.70	112.4
151.83 - 152.44	.61	124.9
152.44 - 152.74	.30	108.7
152.74 - 153.35	.61	105.7
153.35 - 153.96	.61	124.9
153.96 - 154.57	.61	110.3
154.57 - 155.18	.61	83.3
155.18 - 155.79	.61	38.3
155.79 - 156.40	.61	82.4
156.40 - 157.01	.61	142.8

CANADIAN OCCIDENTAL PETROLEUM LIMITED ALBERT MINES NO.2 ASSAY DATA (continued)

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
157.01 - 157.62	.61	142.8
157.62 - 158.23	.61	118.2
158.23 - 158.84	.61	92.8
158.84 - 159.45	.61	16.7
159.45 - 160.06	.61	54.1
160.06 - 160.67	.61	90.8
160.67 - 161.28	.61	124.1
161.28 - 161.89	.61	199.8
161.89 - 162.50	.61	229.0
162.50 - 163.11	.61	212.3
163.11 - 163.72	.61	154.9
163.72 - 164.33	.61	111.9
164.33 - 164.94	.61	152.8
164.94 - 165.55	.61	191.5
165.55 - 166.16	.61	166.5
166.16 - 166.77	.61	157.8
166.77 - 167.38	.61	179.0
167.38 - 167.99	.61	199.8
167.99 - 168.60	.61	108.2
168.60 - 169.21	.61	94.9
169.21 - 169.82	.61	191.5
169.82 - 170.43	.61	148.6
170.43 - 171.04	.61	135.7
171.04 - 171.65	.61	148.2
171.65 - 172.26	.61	131.1
172.26 - 172.87	.61	116.6
172.87 - 173.48	.61	152.0
173.48 - 174.09	.61	135.3
174.09 - 174.70	.61	152.0
174.70 - 175.31	.61	161.1
175.31 - 175.92	.61	128.2
175.92 - 176.53	.61	143.6
176.53 - 177.14	.61	152.0
177.14 - 177.75	.61	135.7
177.75 - 178.36	.61	135.7
178.36 - 178.97	.61	112.4
178.97 - 179.58	.61	124.9

CANADIAN OCCIDENTAL PETROLEUM LIMITED ALBERT MINES NO.2 ASSAY DATA (continued)

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
179.58 - 180.19	.61	133.6
180.19 - 180.80	.61	100.8
180.80 - 181.41	.61	92.0
181.41 - 182.02	.61	132.0
182.02 - 182.63	.61	135.3
182.63 - 183.24	.61	139.5
183.24 - 183.85	.61	159.9
183.85 - 184.46	.61	99.9
184.46 - 185.07	.61	137.4
185.07 - 185.68	.61	104.5
		AVG. 114.3

CANADIAN OCCIDENTAL PETROLEUM LIMITED ALBERT MINES NO.4 ASSAY DATA

ELEVATION: 103.7 m
LENGTH: 520.7 m

INCLINATION: -90°
AZIMUTH: ---------

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
447.56 - 449.09	1.53	82.4
449.09 - 450.61	1.52	125.3
450.61 - 452.13	1.52	114.9
452.13 - 453.66	1.53	89.5
453.66 - 455.18	1.52	107.4
455.18 - 456.70	1.52	82.4
456.70 - 458.23	1.53	167.0
458.23 - 459.76	1.53	102.0
459.76 - 461.28	1.52	104.1
461.28 - 462.80	1.52	111.6
462.80 - 464.33	1.53	76.6
464.33 - 465.85	1.52	48.3
465.85 - 467.38	1.53	66.6
467.38 - 468.90	1.52	38.3
468.90 - 470.43	1.53	84.9
470.43 - 471.95	1.52	62.0
471.95 - 473.48	1.53	148.2
473.48 - 475.00	1.52	85.3
475.00 - 476.52	1.52	88.3
476.52 - 478.05	1.53	126.2
478.05 - 479.57	1.52	125.3
479.57 - 481.10	1.53	103.7
481.10 - 482.62	1.52	85.8
482.62 - 484.15	1.53	113.7
484.15 - 485.67	1.52	116.6
485.67 - 487.20	1.53	62.0
487.20 - 488.72	1.52	117.4
488.72 - 490.24	1.52	99.1
490.24 - 491.77	1.53	57.9
491.77 - 493.29	1.52	102.4
		AVG. 96.5

CANADIAN OCCIDENTAL PETROLEUM LIMITED ALBERT MINES NO.5 ASSAY DATA

ELEVATION: 114.3 m
LENGTH: 871.0 m

INCLINATION: -90°
AZIMUTH: ---------

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
192.07 - 193.60	1.53	83.7
193.60 - 195.12	1.52	72.4
195.12 - 196.65	1.53	85.3
196.65 - 198.17	1.52	134.9
198.17 - 199.70	1.53	120.3
199.70 - 201.22	1.52	99.5
201.22 - 202.74	1.52	92.0
202.74 - 204.27	1.53	65.8
204.27 - 205.79	1.52	97.0
205.79 - 207.32	1.53	128.2
207.32 - 208.84	1.52	168.2
208.84 - 210.37	1.53	157.0
210.37 - 211.89	1.52	78.3
211.89 - 213.41	1.53	66.2
213.41 - 214.94	1.53	75.8
214.94 - 216.46	1.52	92.0
216.46 - 217.99	1.53	57.0
217.99 - 219.51	1.52	60.4
219.51 - 221.04	1.53	64.1
221.04 - 222.56	1.52	82.9
222.56 - 224.09	1.53	124.5
224.09 - 225.61	1.52	141.6
225.61 - 227.13	1.52	153.6
227.13 - 228.66	1.53	148.2
228.66 - 230.18	1.52	74.9
230.18 - 231.71	1.53	95.3
231.71 - 233.23	1.52	114.1
233.23 - 234.76	1.53	130.3
234.76 - 236.28	1.52	154.9
236.28 - 237.80	1.52	125.7
237.80 - 239.33	1.53	107.4
239.33 - 240.85	1.52	90.3
240.85 - 242.38	1.53	107.0
242.38 - 243.90	1.52	141.1
243.90 - 245.43	1.53	101.6
245.43 - 246.95	1.52	93.3
246.95 - 248.48	1.53	67.4

CANADIAN OCCIDENTAL PETROLEUM LIMITED ALBERT MINES NO.5 ASSAY DATA (continued)

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
248.48 - 250.00	1.52	44.5
250.00 - 251.52	1.52	103.3
251.52 - 253.05	1.53	190.7
253.05 - 254.57	1.52	201.9
254.57 - 256.10	1.53	148.2
256.10 - 257.62	1.52	153.6
257.62 - 259.15	1.53	146.1
259.15 - 260.67	1.52	131.6
260.67 - 262.20	1.53	146.1
262.20 - 263.72	1.52	124.1
263.72 - 265.24	1.52	124.1
265.24 - 266.77	1.53	109.1
266.77 - 268.29	1.52	127.8
268.29 - 269.82	1.53	113.7
269.82 - 271.34	1.52	193.6
271.34 - 272.87	1.53	125.3
272.87 - 274.39	1.52	94.9
274.39 - 275.91	1.52	127.8
275.91 - 277.44	1.53	113.7
		AVG. 113.8

CANADIAN OCCIDENTAL PETROLEUM LIMITED ALBERT MINES NO.6 ASSAY DATA

ELEVATION: 120.4 m
LENGTH: 479.6 m

INCLINATION: -90°
AZIMUTH: ---------

SAMPLE INTERVAL m	LENGTH m	OIL, FISCHER ASSAY L/tonne
89.84 - 91.46	1.52	103.3
91.46 - 92.99	1.53	87.8
92.99 - 94.51	1.52	85.3
94.51 - 96.04	1.53	93.7
96.04 - 97.56	1.52	72.4
97.56 - 99.09	1.53	80.8
99.09 - 100.61	1.52	84.9
100.61 - 102.13	1.52	104.1
		AVG. 89.0

CANADIAN OCCIDENTAL PETROLEUM LIMITED ALBERT MINES NO.81-9 ASSAY DATA

ELEVATION: 95.5 m
LENGTH: 123.0 m

INCLINATION: -90°
AZIMUTH: ---------

SAMPLE INTERVAL m	LENGTH m	OIL, CALCULATED L/tonne
10.98 - 12.20	1.22	119.2
12.20 - 13.41	1.21	87.6
13.41 - 14.63	1.22	56.9
14.63 - 15.85	1.22	79.5
15.85 - 17.07	1.22	71.6
17.07 - 18.29	1.22	99.7
18.29 - 19.51	1.22	83.1
19.51 - 20.73	1.22	78.8
20.73 - 21.95	1.22	57.0
21.95 - 23.17	1.22	119.5
23.17 - 24.39	1.22	115.0
24.39 - 25.61	1.22	67.6
25.61 - 26.83	1.22	53.9
26.83 - 28.05	1.22	101.9
28.05 - 29.27	1.22	81.9
29.27 - 30.49	1.22	198.7
30.49 - 31.71	1.22	154.8
31.71 - 32.93	1.22	80.8
32.93 - 34.15	1.22	99.1
34.15 - 35.37	1.22	128.2
		AVG. 96.7

GEOLOGY OF ALBERT MINES

PART OF 21 H/15

PLATE 87-62 (R)

64°42'30" 64°42'00" 64°41'30"

45°53'00"

45°52'30"

BLOCK 1

BLOCK 2

BLOCK 3

FREDERICK BROOK FAULT

WRIGHT FAULT

GESNER FAULT

Mw_c Mw_f Ma_f Ma_c Ma_s Mh MPe Pbp P€

COXY 76-1 COXY 76-4(-90°) COXY 76-5(-90°) COXY 76-6(-90°) COXY 76-7(-90°) COXY 76-2 (-90°) COXY 81-8 COXY 81-9(-90°) ARCO I A(-60°) ARCO I (-45°)

NEW BRUNSWICK MAP

LEGEND

PENNSYLVANIAN
PETITCODIAC GROUP

Pbp — Boss Point Formation
Grey quartzose sandstone an
minor grey and red mudston

MISSISSIPPIAN - PENNSYLVANI
HOPEWELL GROUP

MPe — Enragé Formation
Red to locally grey polymict
grey sandstone; minor red m

UPPER DEVONIAN - MISSISSIP
HORTON GROUP

Mh — Moncton Formation
Hillsborough Member: red to
conglomerate, minor red sa

Mw_f / Mw_c — Weldon Member: Mw_c; grey
polymictic pebble-boulder
and red muddy sandstone
greyish green mudstone; m
conglomerate and nodular l

Albert Formation

Ma_f / Ma_s / Ma_c — Ma_c; grey, fine- to coarse-
polymictic, pebble-boulder
kerogenous siltstone and s
slightly to moderately kero
grey sandstone, siltstone, sh
shale (oil shale) less than
to highly kerogenous shale

PRECAMBRIAN
COLDBROOK GROUP

P€ — Felsic and mafic volcanic

SYMBOL

Bedding, tops known (incline

Bedding, tops unknown (incl

Minor fold (plunge indicate

Drag fold (plunge indicated

Syncline (approximate trace
plunge indicated)

Anticline (approximate trac
plunge indicated)

Rock outcrop

Geological boundary (appro

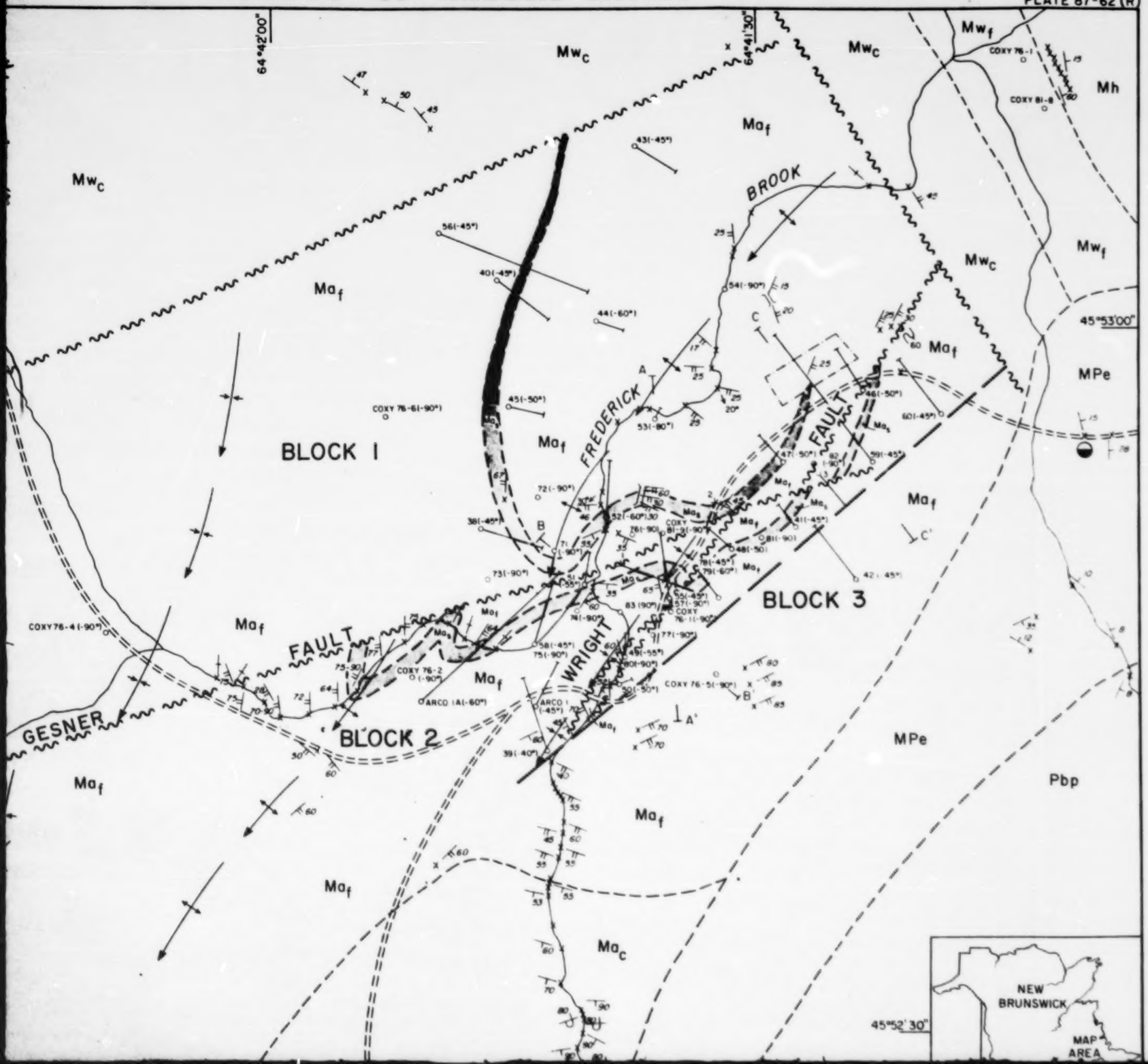
Fault (approximate)

Dead oil stain

Vein (albertite)

GEOLOGY OF ALBERT MINES

PLATE 87-62 (R)



LEGEND

PENNSYLVANIAN
PETITCODIAC GROUP

Pbp — Boss Point Formation
Grey quartzose sandstone and quartz-pebble conglomerate; minor grey and red mudstone

MISSISSIPPIAN - PENNSYLVANIAN
HOPEWELL GROUP

MPe — Enragé Formation
Red to locally grey polymictic conglomerate, red to locally grey sandstone; minor red mudstone

UPPER DEVONIAN - MISSISSIPPIAN
HORTON GROUP

Mh — Moncton Formation
Hillsborough Member: red to locally grey, poorly sorted polymictic conglomerate, minor red sandstone and mudstone

Weldon Member: Mwc; greyish green and red poorly sorted polymictic pebble-boulder conglomerate; minor greyish green and red muddy sandstone and mudstone; Mwf; red to locally greyish green mudstone; minor muddy sandstone and conglomerate and nodular limestone

Albert Formation

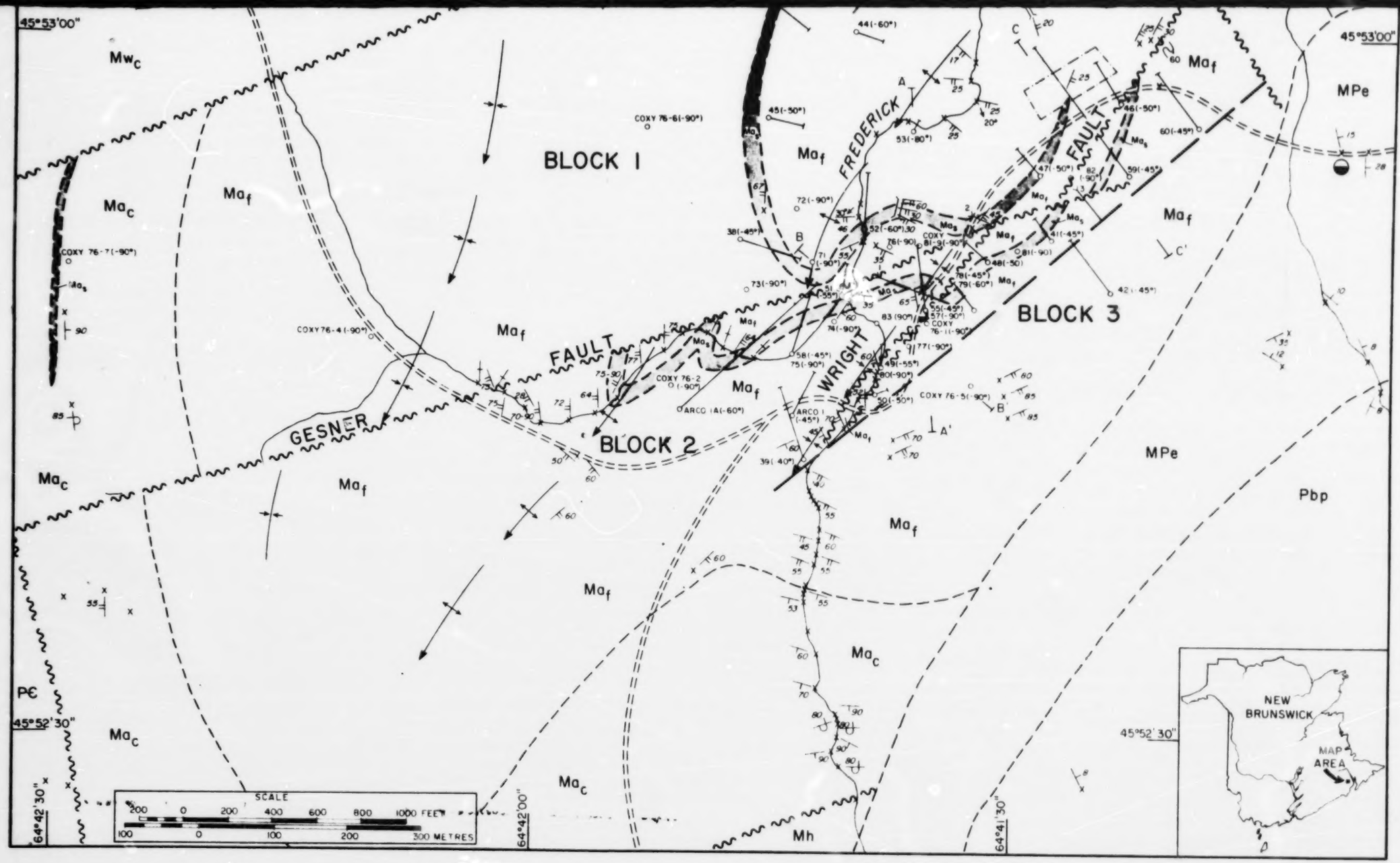
Mac, grey, fine- to coarse-grained sandstone, greenish grey, polymictic, pebble-boulder conglomerate, grey mudstone; minor kerogenous siltstone and shale, and limestone; Maf; brown, slightly to moderately kerogenous siltstone and shale; minor grey sandstone, siltstone, shale, and beds of highly kerogenous shale (oil shale) less than 5m thick; Mas; brown, moderately to highly kerogenous shale (oil shale)

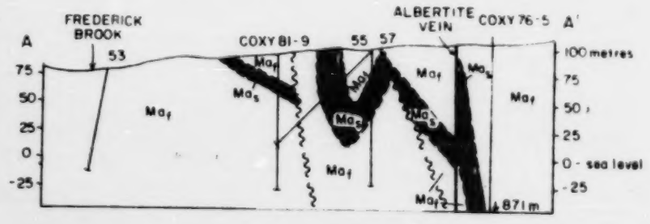
PRECAMBRIAN
COLDBROOK GROUP

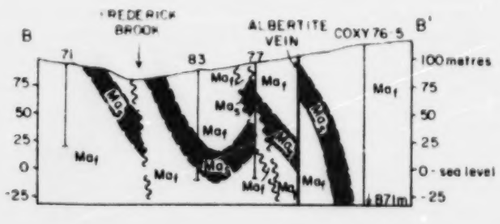
Pc — Felsic and mafic volcanic flows and tuffs

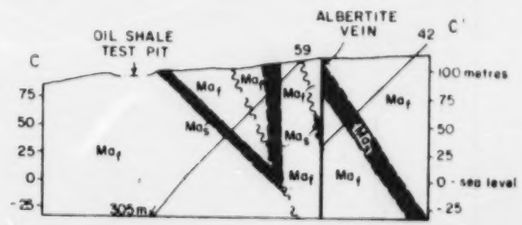
SYMBOLS

- Bedding, tops known (inclined, vertical, overturned)
- Bedding, tops unknown (inclined, vertical)
- Minor fold (plunge indicated)
- Drag fold (plunge indicated)
- Syncline (approximate trace of axial surface, direction of plunge indicated)
- Anticline (approximate trace of axial surface, direction of plunge indicated)
- x — Rock outcrop
- Geological boundary (approximate)
- Fault (approximate)
- Dead oil stain
- Vein (albertite)









Weldon Member : Mwc ; gre
polymictic pebble-boulder
and red muddy sandstone
greyish green mudstone;
conglomerate and nodular

Albert Formation

Mac, grey, fine- to coarse-
polymictic, pebble-boulder
kerogenous siltstone and s
slightly to moderately kero
grey sandstone, siltstone, s
shale (oil shale) less than
to highly kerogenous shale

PRECAMBRIAN

COLDBROOK GROUP

PC Felsic and mafic volcanic

SYMBOL

Bedding, tops known (incline

Bedding, tops unknown (incl

Minor fold (plunge indicate

Drag fold (plunge indicated)

Syncline (approximate trace
plunge indicated)

Anticline (approximate trac
plunge indicated)

Rock outcrop

Geological boundary (approx

Fault (approximate)

Dead oil stain

Vein (albertite)

Trench

Oil shale test pit

Tunnel (abandoned and coll

Drill hole (company name an
from horizontal)

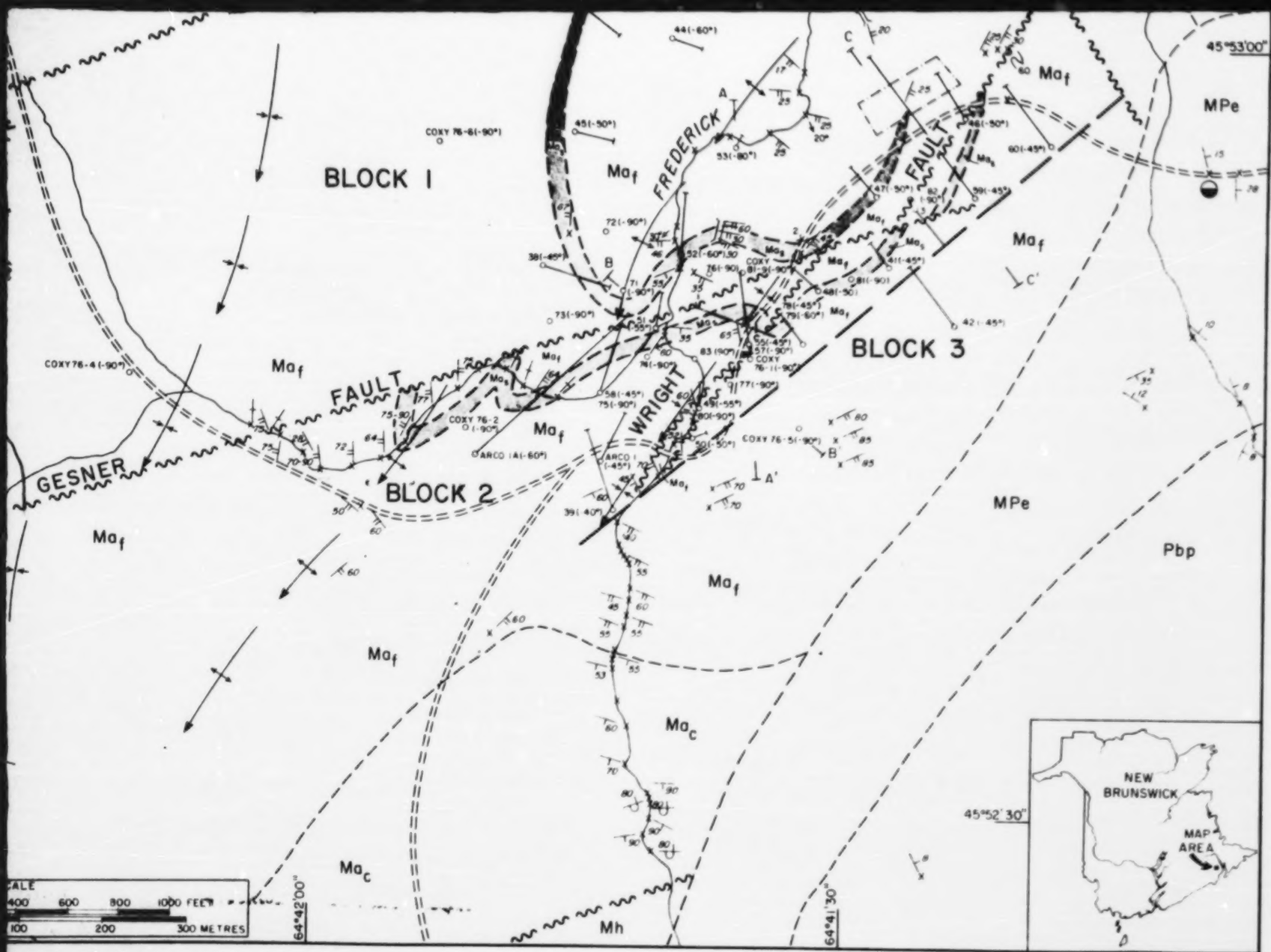
ARCO 1 (-60°)

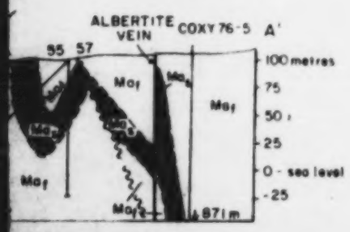
Drill holes by: ARCO - Atlan
COXY - Cano
Unnamed - Go

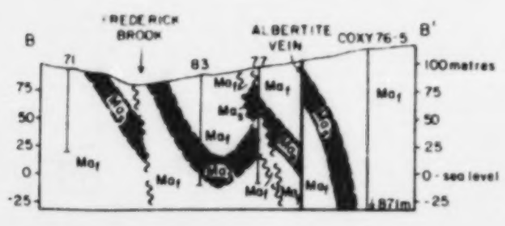
A A' Cross-section location

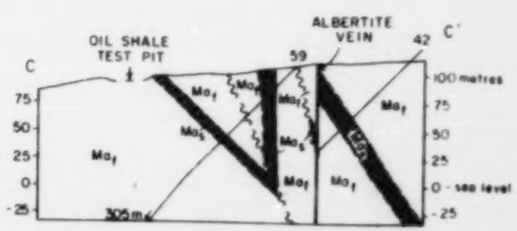
Geology by: C. St. Peter (198

Geology of organic-rich oil shale bed at Albert Mines. See Plate 88-4 for location.









ology of organic-rich oil shale bed at Albert Mines. See Plate 88-4 for location.

conglomerate, minor red sandstone and mudstone

Weldon Member : Mw_c ; greyish green and red poorly sorted polymictic pebble-boulder conglomerate ; minor greyish green and red muddy sandstone and mudstone; Mw_f; red to locally greyish green mudstone; minor muddy sandstone and conglomerate and nodular limestone

Albert Formation

Ma_c , grey, fine- to coarse-grained sandstone, greenish grey, polymictic, pebble-boulder conglomerate, grey mudstone; minor kerogenous siltstone and shale, and limestone; Ma_f ; brown, slightly to moderately kerogenous siltstone and shale ; minor grey sandstone, siltstone, shale, and beds of highly kerogenous shale (oil shale) less than 5m thick; Ma_s ; brown, moderately to highly kerogenous shale (oil shale)

PRECAMBRIAN

COLDBROOK GROUP

PC Felsic and mafic volcanic flows and tuffs

SYMBOLS

- Bedding, tops known (inclined, vertical, overturned)
- Bedding, tops unknown (inclined, vertical)
- Minor fold (plunge indicated)
- Drag fold (plunge indicated)
- Syncline (approximate trace of axial surface, direction of plunge indicated)
- Anticline (approximate trace of axial surface, direction of plunge indicated)
- Rock outcrop
- Geological boundary (approximate)
- Fault (approximate)
- Dead oil stain
- Vein (albertite)
- Trench
- Oil shale test pit
- Tunnel (abandoned and collapsed)
- Drill hole (company name and number, inclination from horizontal)
  Drill holes by: ARCO - Atlantic Richfield Company
  COXY - Canadian Occidental Petroleum Ltd.
  Unnamed - Government of Canada
- A — A' Cross-section location

Geology by: C. St. Peter (1987)

64°51'
50'
45'
40'
35'
46°00'
55'

NEW BRUNSWICK

MAP AREA

FIGURE 5

Stoney Creek
Dover
Gautreau Village
Saint-Joseph
Pré-d'en-Haut
PETITCODIAC
Weldon
Dawson
East Branch
Turtle Creek
HILLSBOROUGH
Boudreau Village
Salem
Beech Hill
Edgetts Landing
Frederick Brook
RIVER

Cartago Resource

45'

40'

35'

PLATE 88-4

64°30'

46°00'

55'

Stoney Creek

Dover

Memramcook East

Memramcook Lake

College Bridge

Saint-Joseph

FIGURE 5

Gautreau Village

Pré-d'en-Haut

MAP AREA

PETITCODIAC

Weldon

Upper Dorchester

Taylor Village

HILLSBOROUGH

Middleton

Boudreau Village

RIVER

Salem

Beech Hill

Edgetts Landing

Frederick Brook

MEMRAMCOOK

Dorchester

PLATE 87-62(B)

Cartago Resources Ltd.,

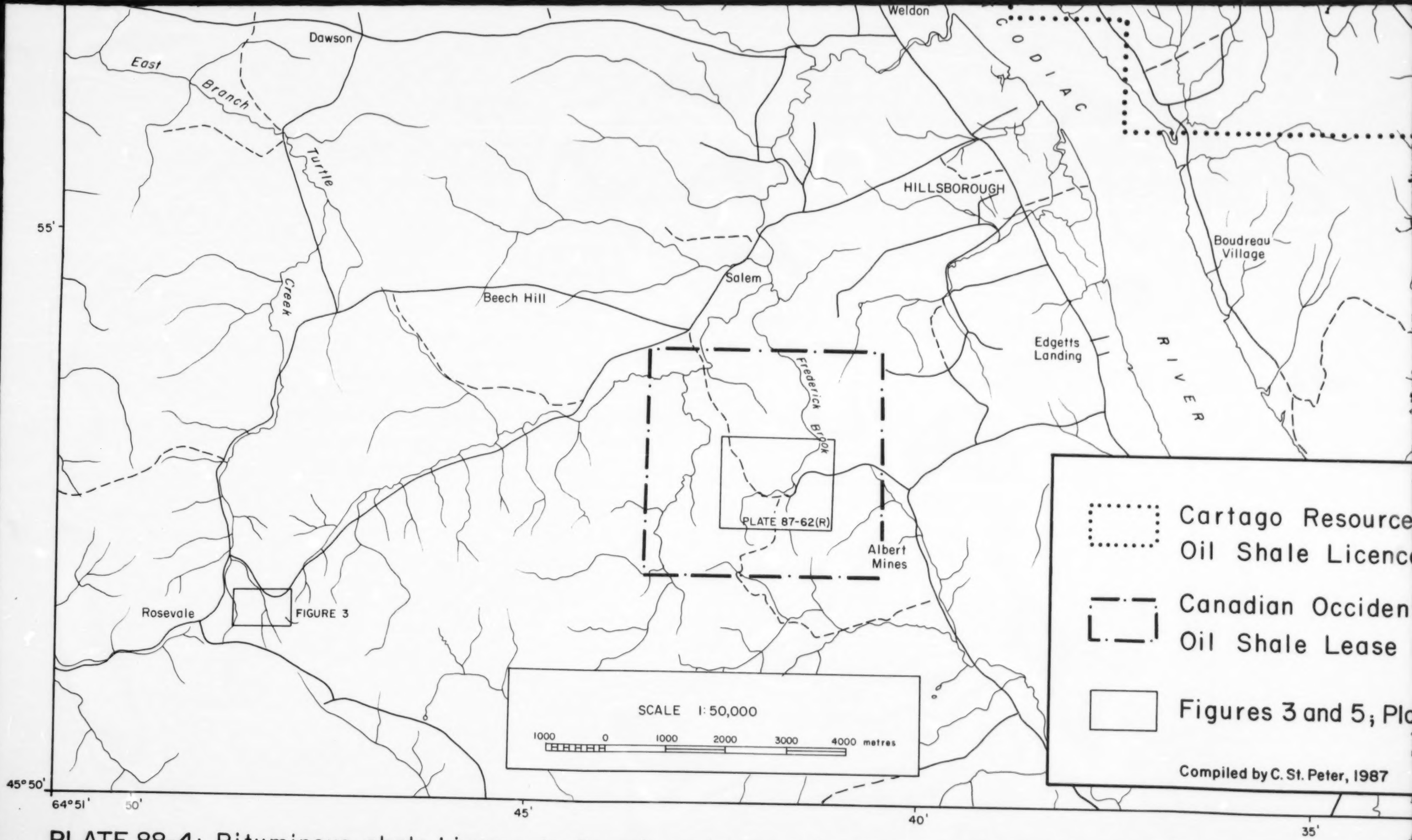


PLATE 88-4: Bituminous shale Licence to Search and Lease location map (and index to Figures 3 and 5; Plate 8
New Brunswick)

Weldon

C O D I A C

HILLSBOROUGH

Salem

Beech Hill

Edgetts Landing

R I V E R

Boudreau Village

Taylor Village

Upper Dorchester

Middleton

RIVER

MEMRAMCOOK

Dorchester

55'

Frederick Brook

PLATE 87-62(R)

Albert Mines

SCALE 1:50,000

1000 0 1000 2000 3000 4000 metres

Cartago Resources Ltd.,
Oil Shale Licence To Search

Canadian Occidental Petroleum,
Oil Shale Lease

Figures 3 and 5; Plate 87-62 (R) (see text)

Compiled by C. St. Peter, 1987

45'

40'

35'

45°50'

64°30'

shale Licence to Search and Lease location map (and index to Figures 3 and 5; Plate 87-62(R), southeastern
ick)